This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

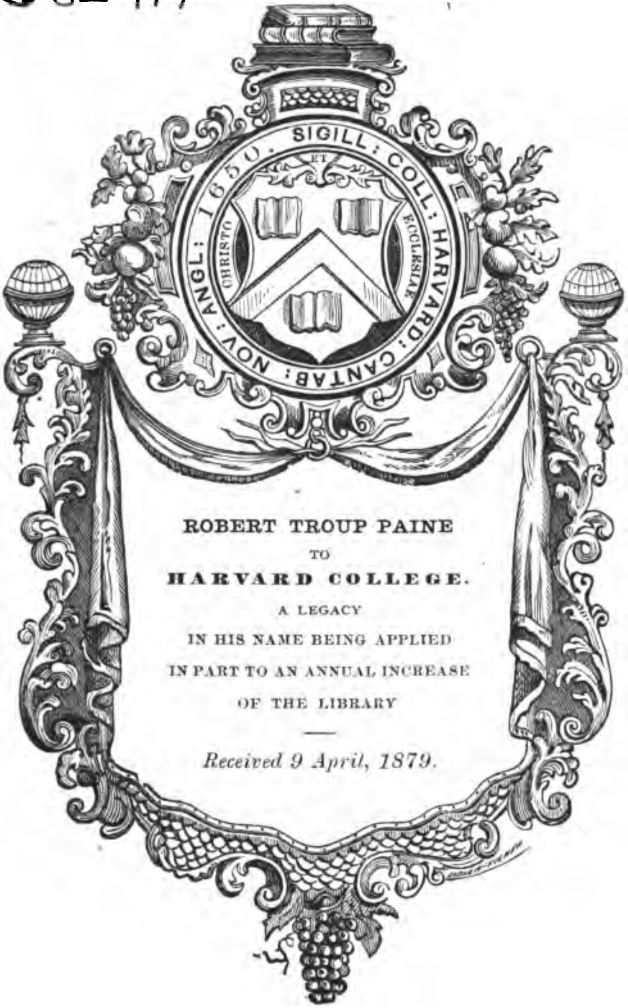
About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

NEDL TRANSFER
HN 2DB6 T

KD 62917

Bd. Aug. 1896



ROBERT TROUP PAINE
TO
HARVARD COLLEGE.
A LEGACY
IN HIS NAME BEING APPLIED
IN PART TO AN ANNUAL INCREASE
OF THE LIBRARY

Received 9 April, 1879.

57,159

An EXPERIMENTAL
INQUIRY
On ſome PARTS of the
Animal Structure.

7

BOOKS printed for J. WALTHOE.

1. *Commentarium Noſologicum, Morbos Epidemicos, & Aeris Variationes, in Urbe* Eboracenſi, *Lociſque vicinis, per ſedecim Annos graſſantes complectens. Auctore* CLIFTONO WINTRINGHAM, M.D.

2. Obſervations on the different *Strata* of *Earths* and *Minerals*. By JOHN STRACHEY, Eſq; F.R.S.

3. R. WELSTED, M.D. *de Medicina Mentis.*

4. Dr. FREIND'S HISTORY of PHYSIC, from the Time of *Galen*, to the Beginning of the Sixteenth Century; chiefly with regard to Practice. In a Diſcourſe written to Dr. *Mead*. The Third Edition, in Two Volumes, *Octavo.*

5. *T. Lucretius Carus*, of the Nature of Things. Tranſlated into *Engliſh* Verſe, by *Thomas Creech*, M.A. The Sixth Edition, illuſtrated with Notes, making a complete Syſtem of the *Epicurean* Philoſophy. In Two Volumes, *Octavo.*

[redacted] Troup Paine
to Harvard College

AN EXPERIMENTAL

INQUIRY

On ſome PARTS of the

Animal Structure.

By CLIFTON WINTRINGHAM, *junior*.

> —*Ex iis, quæ Experimentis conſtant, ducere tentemus quicquid poteſt, antequam in Hypotheſes liberiores expatiemur: Non male cæperunt* Sanctorius, Jungius, Redius, Borellus, Stenonius, Wepferus, Brunnerus, Bellinus, Spoletus, Tſhirnauſius, Bernoullius, Liſterus, Pitcarnius, *aliique etiam in* Gallia, *&* *alibi egregii Viri; ſed adhuc in primis Viis hæremus, optandumque eſt, ut ab iis Initium fiat, quæ Praxi Medicæ ſunt proxima.*
>
> LEIBNITZ.

LONDON:

Printed for J. WALTHOE, over-againſt the *Royal*
Exchange in *Cornhill.* M.DCC.XL.

~~51.159~~
~~Z 14.008 W1~~
737-56
KD 62917

1879, April 9.
Paine bequest.

HARVARD
UNIVERSITY
LIBRARY
JUN 13 19[illegible]2

THE INTRODUCTION.

THAT the Theory of Phyſic has been much improved, and many truths diſcovered by the induſtry of the Moderns, of which the Ancients were intirely ignorant, is a poſition nobody, I believe, will diſpute. But that a great many more relating to every branch of this moſt uſeful Art lie ſtill buried in obſcurity, is equally certain. And what is yet more to be lamented than real ignorance itſelf, is, falſe maxims and poſitions are many times introduced as facts, and aſſumed as Data, whereon to build future inquiries. Anatomy itſelf, tho' it has been more cultivated, and received greater improvements, than any other branch, as lying moſt obvious to our ſenſes, is not free from this error, no not even the largeſt veſſels; what then ſhall we think of ſuch as are more remote?

The fatal ſpring from whence moſt of the errors in the Theoretical part of phyſic have flowed, is, the deducing general concluſions from a few particular Experiments, and on this foundation erecting ſome pompous plauſible Hypotheſis, which like *Deſcartes*'s Vortices may indeed ſhew how the one would have framed the Univerſe, and the other the Animal body; but give us very little light into the real ſtructure of either.

This can only be obtained by a laborious ſearch, and the ſtricteſt examination imaginable, and that too by a vaſt variety of Experiments; as any one may be convinced by the few methods of trial here made uſe of, wherein only the different Denſities, Strengths and Thickneſſes of ſome few of the Solids are conſidered; but much more ſo, if he will give himſelf the trouble of ſuch a variety of Experiments, as are requiſite fully to illuſtrate any branch of this complicated Machine, or thoroughly explain any one particular Secretion; wherein it is impoſſible to advance one ſtep without error, unleſs we be ſupported by undeniable matters of Fact.

The ingenious Dr. *Hales* has given us a few Experiments of the remarkable ſtrength of ſome animal veſſels; but no one, that I know of, has attempted their Compariſon, or afforded us any light towards a diſcovery, on what foundation their different degrees of action on the contained fluids muſt depend.

The Experiments here related are moſtly made on the veſſels of Brutes; but they are all on ſuch parts as are ſimilar to thoſe of human bodies; and that not only becauſe it was ſcarce poſſible to procure a competent number of the latter; many of them, tho' not here mentioned to avoid confuſion, being repeated ten, nay, twenty times over, as well on different Animals of the ſame kind, as thoſe of a different Species, in order to the greater certainty, where that was required;

but chiefly, becauſe it is neceſſary in Experiments of this nature, that the Animal ſhould die in perfect health. The veſſels of Morbid bodies being ſo altered by the force of different diſeaſes, whoſe effects are often quite contrary to each other, and the various changes introduced by the Humours, that no certainty could be derived from trials of that kind. For what is more common in Diſſections of this nature, than to find many veſſels ſo extended, that not only their Capacities vaſtly exceed their proper ſize and dimenſion, but the Coats themſelves are become ſo thin and dilated, as not to equal one-half of their natural Thickneſs? whilſt others, in different caſes, vary from their natural proportion in the contrary extreme, not to mention their Rottenneſs and Corruption, occaſioned by the violence of the diſeaſes, and effects of the Humours upon them, a circumſtance not leſs frequent than either of the other.

AN

AN Experimental INQUIRY

On ſome PARTS of the

Animal Structure.

EXPERIMENT I.

§ I. PART of the Aorta deſcendens of a young man, taken out of the body after it had been dead forty hours, was found to weigh in air by a very nice balance, whoſe beam turned with the twohundredth part of a grain, 5 pennyweights, 16 grains, 75 mites, which name I ſhall uſe for a weight, a hundred of which make up but one grain. Then weighing it in water, its gravity was 7 grains, 75 mites.

§ 2. The weight of part of the Vena cava in the ſame perſon was in air 1 pennyweight, 4 grains, 63 mites; and the ſame counterpoiſed in water, 2 grains, 66 mites.

§ 3. Hence the ſpecific gravity of the great Artery in a man will be to water, in the proportion of 13675 to 12900, that is, nearly as 106 to 100.

§ 4. Hence alſo the ſpecific gravity of the correſponding Vein will be to water, as 2863 to 2597, that is, in the proportion of 1102 to 1000 nearly.

§ 5. Hence by comparing the ſpecific gravities in § 3, 4. together, it is evident, that the Vena cava of this young man exceeded the Aorta of the ſame perſon in denſity in the proportion of 36932700 to 35513975, that is, in the proportion of 26 to 25 nearly.

EXPERIMENT II.

§ 1. Part of the Aorta deſcendens of a calf, taken freſh out of the body, which I always underſtand, if not expreſſed otherwiſe, was found to weigh in air 7 pennyweights, 10 grains, 25 mites. The weight of this in water was 9 grains, 62 mites.

§ 2. Part of the Vena cava of the ſame calf weighed in air 2 pennyweights, 5 grains, 95 mites, and afterwards in water 4 grains, 75 mites.

§ 3. Hence the ſpecific gravity of the Artery to water will be in the proportion of 17825 to 16863, that is, as 1057 to 1000 nearly.

§ 4.

§ 4. Thus alſo the ſpecific gravity of the Vein to the ſame fluid will be in the proportion of 5395 to 4920, that is, as 1096 to 1000 nearly.

§ 5. Hence by comparing theſe ſpecific gravities together, it appears, that the denſity of the great Artery was to that of the correſponding Vein in this animal a calf, in the proportion of 87699000 to 90975885, that is, as 27 to 28 nearly.

EXPERIMENT III.

§ 1. I found the weight of part of the Aorta of a lamb to be in air 2 pennyweights, 14 grains, 44 mites; and afterwards in water it counterpoiſed 3 grains, 23 mites.

§ 2. The weight of part of the Vein correſponding to the preceding Artery was in air 13 grains, 69 mites, and the ſame being weighed in water, its gravity was 1 grain, 16 mites.

§ 3. Hence the ſpecific gravity of the Aorta in this lamb was to water in the proportion of 6244 to 5921, or of 1054 to 1000 nearly.

§ 4. Thus alſo the ſpecific gravity of the Vena cava in the ſame animal was to water in the proportion of 1369 to 1253, or of 1092 to 1000 nearly.

§ 5. Hence comparing the ſpecific gravities of the Vein and Artery in § 3, 4. together, it appears, that the denſity of the great Artery in the lamb was to that of the great Vein in the ſame, in the proportion of 7823732 to 8105849, that is, in the proportion of 250 to 259 nearly.

EXPERIMENT IV.

§ 1. The Aorta of a young boar weighed in air 6 pennyweights, 12 grains, 15 mites, and in water 9 grains, 49 mites.

§ 2. The Vena cava of the ſame boar weighed in air 1 pennyweight, 13 grains, 27 mites; the ſame in water counterpoiſed 3 grains, 55 mites.

§ 3. Hence the ſpecific gravity of the great deſcending Artery in this animal was to water, in the proportion of 15615 to 14666, that is, nearly as 1064 to 1000.

§ 4. Hence alſo the ſpecific gravity of the Vein correſponding to the preceding Artery, will be to water, as 3727 to 3372, that is, in the proportion of 1105 to 1000 nearly.

§ 5. It appears therefore from § 3, 4. that the denſity of the Vena cava in the boar exceeded that of the correſponding Artery in the proportion of

54660182 to 52653780, that is, in the proportion of 519 to 500 nearly.

In order to obtain the Thickneſs of ſuch Veſſels or Membranes as were wanted with the greateſt exactneſs, I took the following method.

Having firſt carefully cleared the part, whoſe Thickneſs I was ſeeking, of all fat, or any other adhering ſubſtance, I carefully ſpread it upon a ſmooth ſurface; and then cutting off by an inſtrument made for that purpoſe, an exact inch ſquare, or ſome determinate portion of it, where ſo much could not be obtained, I let it down into water; hence as bodies immerſed in that fluid, from a principle of Hydroſtatics, poſſeſs ſpaces equal to themſelves in bulk, I found by comparing theſe bulks together, that a quantity of water having the ſame baſe, and equal to the ſolid content of the part immerſed, was of ſuch a preciſe Thickneſs, equal to that of the part before unknown.

EXPERIMENT V.

§ 1. I found by the preceding method, that the Aorta deſcendens of the man mentioned in § 1. EXP. I. was $\frac{1}{9}$ of an inch thick, and the correſponding Vena cava was $\frac{1}{174}$ of an inch thick.

§ 2. The Aorta deſcendens of the calf mentioned at § 1. EXP. II. was $\frac{1}{11}$ of an inch in Thickneſs, and the Vena cava aſcendens of the ſame animal was $\frac{1}{178}$ of an inch thick.

§ 3. The Aorta of the boar, whoſe Denſity was found by EXP. IV. was $\frac{1}{16}$ of an inch in thickneſs, and the Vena cava of the ſame was equal in Thickneſs to $\frac{1}{262}$ of an inch.

§ 4.

§ 4. Hence by comparing the Thickneſſes of the veſſels found in the preceding ſections of this experiment, it is evident, that as Ratio's having the ſame antecedents, are reciprocally as their Conſequents, therefore the Thickneſs of the Aorta of the young man was to that of its correſponding Vein, in the proportion of 154 to 9, that is, nearly as 17 to 1. And the Aorta of the calf is in like manner to its correſponding Vein, in the proportion of 158 to 11, that is, nearly as 14 to 1. Laſtly, the Aorta of the boar exceeds the Thickneſs of the Vena cava aſcendens in the ſame animal in the proportion of 262 to 16, or of 33 to 2, that is, nearly as 16 to 1.

§ 5. From § 5. Exp. I. § 5. Exp. II. § 5. Exp. III, IV. it is obſervable, that this leſs degree of Denſity in the coats of the Arteries to their correſponding

Veins is ſufficiently recompenſed by the Thickneſs of their coats (*a*), and is indeed neceſſary in continuing the life of the animal to its preſent natural period. For the blood in the Arteries being conſtantly impelled from the baſe towards the apex of a Cone, their coats, eſpecially thoſe near the heart, muſt in a much ſhorter time have become bony, had they been as cloſe wrought as thoſe of the Veins, and conſequently the animal would not have lived to the term it now does; the Aorta, and ſometimes even thoſe at a greater diſtance from the Heart, being in old animals frequently found oſſified.

§ 6. This greater Denſity, and more compact Texture, of the coats of the Veins, in proportion to their Thickneſs, than in the Arteries, furniſhes us alſo

---

(*a*) See § 4. Exp. V.

with another inſtance of the infinite wiſdom uſed in the animal ſtructure. For, as there is here no pulſation, the fluid moving from the apex of a Cone, there was no danger of their becoming bony, tho' the texture of their coats be ſo cloſely wrought. But then a ſufficient ſtrength was here likewiſe neceſſary to ſupport the lateral preſſure conſequent upon ſuch an altitude of fluid, which would otherwiſe diſtend their coats, and render them varicoſe, as we ſee it actually does, whenever their coats are weakened by accidents.

§ 7. It may be objected, that the Valves placed in them, by dividing them, as it were, into ſo many cells, are a great preſervative againſt this diſtention; but this is rather a proof, that they neceſſarily required the ſtrength and denſity before-mentioned, ſince where theſe are not placed, and the coats lie naked, and leſs ſupported by the ſurrounding parts, as in the Uterus, &c. varicoſe ſwellings and hæmorrhages frequently enſue. How great then the diſorders muſt have been in almoſt every part of the body in a ſhort time, will appear to every one converſant in Anatomy, had the coats of the Veins been of ſo lax and weak a texture, as they are generally ſuppoſed, nay, are frequently defined by Anatomiſts to be; and not had that degree of denſity and firmneſs, which the experiments above cited at § 5. Exp. V. as well as ſeveral ſucceeding ones, no way depending on theſe, actually ſhew they have. Nay, it might eaſily be demonſtrated, that had their texture been otherwiſe, polypous concretions muſt neceſſarily have been formed in almoſt every Vein, and thence the circulation of the blood have been ſoon obſtructed, and not only ſo, but the Heart could not have been ſupplied with a ſufficient quantity for the animal life, when ſo great a proportion of it remained in the diſtended Veins, as muſt inevitably have enſued on an univerſal weakneſs of their coats, even though we ſhould ſuppoſe the force of the Heart and Arteries increaſed to any degree of ſtrength and thickneſs, that can be imagined conſiſtent with the ſize and ſhape of the animal.

EXPERIMENT VI.

§ 1. I took part of the deſcending Aorta from an old man two days after his death, and having carefully removed all the adhering fat from it, which in theſe as well as the preceeding experiments I always ſuppoſe done, I weighed it in air, and found it equivalent to 8 pennyweights, 5 grains, 43 mites; and in water to 17 grains, 66 mites.

§ 2. The weight of part of the Vena cava aſcendens in the ſame perſon, was in air 2 pennyweights, 18 grains, 7 mites; and the ſame, counterpoiſed in water, no more than 6 grains, 34 mites.

§ 3. Hence the ſpecific gravity of the great Artery in this old man, was to water, in the proportion of 19743 to 17977, that is, of 1098 to 1000 nearly.

§ 4. The ſpecific gravity alſo of the great Vein in the ſame man, will be to water, in the proportion of 6607 to 5973, that is, nearly as 1106 to 1000.

§ 5. From the foregoing experiment we learn, that the great Artery in this old animal was ſo altered by age, and the courſe of a longer circulation, that notwithſtanding the denſity of the like Artery in a young one of the ſame ſpecies, was leſs than that of its correſponding Vein by $\frac{1}{25}$ nearly (*a*), yet in the old one the ſpecific gravity of the ſame veſſel is ſo increaſed as to make it bear to its proper returning Vein, the proportion of 117924939 to 118774039; and conſequently the Vein in the old man exceeds the denſity of its correſponding Artery in no greater proportion than that of 140 to 139.

EXPERIMENT VII.

§ 1. I took part of the deſcending Aorta from an ox 15 years old, and

---

(*a*) See § 5. EXP. I.

having removed the fat, as in the preceeding experiment, I found its weight to be in air 16 pennyweights, 12 grains, and in water 1 pennyweight, 7 grains, 37 mites.

§ 2. The weight of part of the correſponding Vena cava was in air 5 pennyweights, 10 grains, 25 mites, and the ſame, counterpoiſed in water, 12 grains, 2 mites.

§ 3. Hence the ſpecific gravity of the great Artery in this old ox, was to water, in the proportion of 39600 to 36463, that is, of 1086 to 1000 nearly.

§ 4. The ſpecific gravity alſo of the great Vein in the ſame ox, will be to water, in the proportion of 13025 to 11823, that is, nearly in the proportion of 1101 to 1000.

§ 5. It appears therefore, that the denſity of the Aorta in this animal, was to that of its correſponding Vein, in nearly the proportion of 500 to 507.

§ 6. By comparing § 3, 4. of this Exp. with § 3, 4. of Exp. II. it is evident, that the denſity of the deſcending Aorta in this old ox, is to that of the like Artery in a calf, as 1027 to 1000 nearly; and that the denſity of the Vein here does not exceed that of the like Vein in the calf, in ſcarce ſo great a proportion as that of 1005 to 1000.

Experiment VIII.

§ 1. The Aorta of a large old boar, being weighed in air, was equal to 5 pennyweights, 9 grains; and the ſame, counterpoiſed in water, 10 grains, 1 mite.

§ 2. The Vein correſponding to the preceeding Artery, weighed in air 1

1 pennyweight, 11 grains, 9 mites, and in water 3 grains, 33 mites.

§ 3. Hence the ſpecific gravity of the Aorta in this old boar, was to water, in the proportion of 12900 to 11899, that is, nearly as 1084 to 1000.

§ 4. The ſpecific gravity of the Vein, will be to water, in the proportion of 3509 to 3176, that is, nearly as 1105 to 1000.

§ 5. It appears therefore, that the denſity of the deſcending Aorta in this animal, was to that of its correſponding Vein, in the proportion of 40970400 to 4175359, that is, nearly in the proportion of 52 to 53.

§ 6. Hence, by comparing § 3, 4. of this experiment with § 3, 4. of Exp. IV. it appears, that the denſity of this Aorta in the old boar, exceeds that of the like Artery in a young one, in the proportion of 54 to 53 nearly; and further, that the Vein has not in the ſame time increaſed its denſity at all.

EXPERIMENT IX.

§ 1. Part of the great Artery of a young greyhound weighed in air 2 pennyweights, 16 grains, 98 mites; and afterwards in water 3 grains, 62 mites.

§ 2. The correſponding Vein weighed in air 14 grains, 43 mites; and in water it counterpoiſed 1 grain, 30 mites.

§ 3. Hence the ſpecific gravity of the Aorta in this greyhound, was to water, as 6498 to 6136, that is, nearly as 1059 to 1000.

§ 4. Hence alſo, the ſpecific gravity of the Vena cava in the ſame animal, was to water, in the proportion

EXPERIMENT XI.

§ 1. The great Artery of the boar, whoſe denſity we found in EXP. IV. was 0.0625 of an inch thick, and the great Artery of the great old boar, mentioned in EXP. VIII. was 0.094 of an inch in thickneſs. The great deſcending Artery of the greyhound, mentioned in EXP. IX. was 0.046 of an inch in thickneſs, and the Aorta of the old dog, mentioned in the preceeding experiment, was 0.07 of an inch thick.

§ 2. It is evident, that the canals in an animal body, may be conſidered as ſo many cylindrical receivers, filled with a fluid. If now we compare the fluid in the cavity of the Aorta of the boar, whoſe diameter was 0.34 of an inch, with the thickneſs of the coat that contains it, it follows, that as cylinders of equal altitudes are directly as their baſes, therefore the fluid contained within this Artery, will be to its coat, as 1156 to 1006 nearly; and by uſing the ſame method of compariſon with the Aorta of the greyhound, whoſe diameter was 0.26 of an inch, it appears, that the fluid contained within this, is to the ſolid part of the Artery, as 676 to 563 very nearly.

§ 3. By comparing the fluid in the cavity of the Aorta of the old boar and the old dog, with their thickneſſes reſpectively, as they are given in § 1. of this experiment, it is evident, that the fluid contained in the cavity of the firſt, is to its reſpective Artery, whoſe diameter was 0.45 of an inch, in the proportion of 202 to 204 nearly; and the fluid contained in the Aorta of the old dog, whoſe diameter was 0.33 of an inch, and its thickneſs 0.07 of an inch, will bear to the coat of its reſpective Artery, the proportion of 1089 to 1120 nearly.

§ 4. It is therefore evident from the two preceeding ſections, that the fluid contained in the cavity of the Aorta of the young boar, and of the greyhound, bear a larger proportion, with reſpect to the coats of thoſe Arteries, than thoſe circulating in the cavity of an Aorta of the old animal of the ſame ſpecies, bear with relation to theirs; theſe laſt being to the former, with regard to the bulk of their containing coats, in the proportion compounded of the direct ratio of the fluids, and the reciprocal one of the ſolids they act upon; which proportion appears from computation to be, that of 203212 to 235824, and 613107 to 757120 reſpectively, that is, nearly as 1000 to 1160, and 1234, for each particular ratio.

§ 5. It appears highly probable, that the denſities of the Arteries, being changed by age, to the very reverſe of what they were in young animals (*a*), may well be eſteemed as the principal cauſe in limiting their growths, and confining them to their natural ſize and proportion. For the impulſe of the blood being much greater in ſuch veſſels, as ſpring immediately from the Aorta, than thoſe more remote, theſe muſt be firſt diſtended, and that too in length, in a greater proportion than in their diameters, as is manifeſt from the nature of the cone, through which they circulate, whoſe ſmall diminution in its trunk between each ramification,

---

(*a*) See § 5. Exp. VI. § 5, 6. Exp. VII, VIII, X.

joined with the quantity of blood drawn from the trunk by each branch, muſt diminiſh the lateral impetus in a greater ratio than the longitudinal, as is evident not only from the doctrine of Conics and Hydraulics, but appears, even to our ſenſes, in ſuch veſſels, as are partially compreſſed, or obſtructed, in all which the lateral impetus is increaſed, and thereby tumors produced.

This then being the ſtructure of the animal veſſels, it is evident, that theſe muſt grow both in length and diameter, though in a greater proportion in the former, than the latter, till ſuch time as their coats have acquired ſuch a degree of firmneſs, as to put them in æquilibrium with the impetus of the fluids upon them; at which ſtate when the animal is once arrived, it can grow no taller.

But though the veſſels immediately ſpringing from the Aorta, where the impetus upon them is greateſt, have acquired this degree of firmneſs and denſity, it is manifeſt, that the collateral veſſels, which derive their juices, as it were, at ſecond-hand, muſt remain much weaker, and more eaſily diſtenſible; and conſequently the proportion of blood, which was required to the diſtention of the former, muſt paſs into theſe, and that too with greater force than before, by reaſon of the increaſed ſtrength of the primary veſſels; theſe then muſt be next diſtended in their deſtined proportion, till their acquired ſtrength puſh on the juices to exert their force to all ſucceeding ramifications, in their natural order and proportion; which done, the animal has acquired the full ſtrength and proportion its veſſels are capable of. Conſonant to which, we ſee, that young animals, though equally tall with thoſe of the ſame ſpecies which are older, are always more weak, lax, and ſlender, than ſuch as are full grown, where every part has acquired its due firmneſs and denſity, and is ſufficiently repleniſhed with its proper juices.

The ſolids and fluids being thus reduced to a juſt æquilibrium through the whole body, the animal will remain in this ſtate, or at leaſt be leſs liable to changes than before, till ſuch time as, by the continued action of the ſolids and fluids upon each other, the caſe become conſiderably altered, as it neceſſarily muſt be from the increaſing denſity of the ſolids. Hence the coats of the arterial veſſels will be contracted, and reſiſt the fluids more ſtrongly; and if the ſame quantity of nouriſhment be continued, the redundant quantity muſt be thrown off upon ſuch parts as are moſt lax and diſtenſible, of which kind are the Abdomen and adipoſe Cells, as daily experience confirms in this ſtate of the animal life, both in men and brutes.

The ſame cauſe, *viz.* the increaſing rigidity and denſity of the ſolids, ſtill continuing (*a*), its effect muſt do ſo likewiſe, and conſequently all the ſolids of the body become more rigid and contracted.

But this increaſing denſity and rigidity of the Arteries, is not the ſole effect produced by age. For the proportion of the coat to the cavity of the Veſſel is conſiderably altered, as appears by § 4. Exp. XI. wherein the thickneſs of the coat of the Aorta in

---

(*a*) See § 5, 6. Exp. VII. to Exp. X.

the old dog, bears a much greater proportion to the contained fluid, than in the young one, and that without any allowance for the greater moiſture, and more ſupple texture in the coats of the latter; and conſequently whatever force is neceſſary to excite any degree of motion in the Fibres of the younger animal, muſt be increaſed, if we would produce an equal effect on the Fibres and Veſſels of the old one.

Hence then, a greater influx of ſpirits muſt be neceſſary to actuate an old animal, than one that is younger; but this being impoſſible to be ſupplied from a leſs proportion of blood, and that too not equally elaborated, through the ſame defect in the ſecretory organs, the animal muſt of neceſſity grow torpid and unactive; the force exerted by the muſcles, muſt be more weak and feeble, and inſtead of that ſteadineſs in the limbs, which ariſes from a regular and ſufficient derivation of the nervous fluid, a tremor enſue, the antagoniſt muſcles being ſtimulated to frequent ineffectual contractions, by an inſufficient and irregular derivation in the old, which are firmly braced, and ſufficiently ſupplied in the younger animal. Hence the muſcular parts muſt become ſhriveled, be leſs fit for their proper functions, and the animal unable to perform its accuſtomed motions and exerciſes, a ſtate of life moſt elegantly deſcribed by the poet (*a*):

——— Quam continuis & quantis longa ſenectus
Plena malis! deformem & tetrum ante omnia vultum,
Diſſimilemque ſui, deformem pro cute pellem.
Plurima ſunt juvenum diſcrimina, pulchior ille
Hoc, atque ille alio, multum hic robuſtior illo:

(*a*) JUVENAL, Sat. X.

Una ſenum facies, cum voce trementia membra,
Et jam læve caput, madidique infantiâ naſi.
Præterea minimus gelido jam corpore ſanguis
Febre calet ſolâ, circumſilit agmine facto
Morborum omne genus——

§ 6. Hence alſo appears the reaſon of the different diſeaſes incident to young and old animals, as alſo why many of the former ſhall gradually wear off, and frequently diſappear, as the animal approaches to its greateſt ſtrength and maturity, without any aſſiſtance from art; many veſſels, before too weak to perform their deſtined offices with proper vigour, daily acquiring more ſtrength and firmneſs.

Nor is it leſs apparent, why thoſe incident to age ſhould conſtantly increaſe, even where the greateſt ſkill is applied to prevent it. For theſe conſiſting moſtly of obſtructions, ariſing primarily from the contraction and rigidity of the canals, muſt keep pace with the increaſing cauſe, and prove incurable by the moſt ſkilful phyſician.

§ 7. I might here alſo ſhew the fallacy of an aſſertion of the late ingenious Dr. *Keil*, which is ſtill adhered to by moſt Anatomiſts, *viz.* that Accretion and Nutrition conſiſt only in the diſtention of veſſels; which is manifeſtly falſe from their increaſing denſity and firmneſs. Nay, it might eaſily be made appear, that was this the caſe, the animal muſt daily grow weaker, the nearer it approached to maturity; and not only ſo, but conſidering the ſize of an embryo, with regard to that of a full grown animal of the ſame ſpecies, its moſt firm and compact parts would not exceed the cohæſion of the thinneſt gelly.

'Tis true, indeed, that the coats of the Veſſels conſiſt of others that are ſmaller, and theſe again of others, to the minuteſt ramifications imaginable, and that by the diſtention of theſe, the coats of the largeſt increaſe in thickneſs; but this alone will not account for their increaſing denſity, which neceſſarily ſuppoſes an addition of matter in the ſame bulk; and conſequently muſt ariſe not ſolely from diſtention, but likewiſe from the appoſition of freſh particles into ſuch pores and interſtices, as by the diſtention of the coats are qualified to receive them, which are there fixed and conſolidated by the conſtant impulſe of the fluids upon them; and that more eſpecially during ſleep, when the circulation is equable and regular, and not diſturbed by the action of the muſcles.

It were eaſy hence to ſhew the vaſt difference betwixt Nutrition properly ſo called, and Repletion, or ſuch a diſtention of the veſſels, which apes it, were it not digreſſing too far from my preſent deſign.

§ 8. Hence appears the unreaſonableneſs of that practice, which forbids the uſe of bleeding in diſtempers of old perſons, though recommended and practiſed with great advantage to younger ones in diſeaſes of the ſame ſpecies. For though the coats of the Arteries bear a greater proportion to their contents in theſe than young animals (*a*), and conſequently the quantity of fluids be proportionably leſs in the firſt, than in the latter; yet, as the Arteries, in which obſtructions are principally formed, are apparently more denſe and rigid, and cannot be

---

(*a*) See § 4. Exp. XI.

ſo dilated, as in many caſes is requiſite; it follows, that where either Revulſion is abſolutely neceſſary, or inflammations to be reſolved, whoſe continuance or ſuppuration would be deſtructive of the life or well-being of the ſick, this inconvenience muſt be diſpenſed with.

'Tis true, indeed, a leſs quantity will generally ſuffice; but that is no reaſon, why an evacuation, ſo neceſſary, ſhould be totally omitted.

§ 9. Nor is it leſs apparent from hence, that the quantity of nouriſhment taken by old perſons, ſhould be leſs than in thoſe that are younger; and that too, gradually diminiſhed in very old age, conſonant to the advice of HIPPOCRATES, and the practice of the famous *Venetian* CORNARO; the expence by perſpiration, and ſeveral other Emunctories, being not only leſs, and thence a leſs recruit neceſſary, but the cavities of the containing veſſels diminiſhed, and withal ſo rigid, as not eaſily to yield either to the receipt or diſcharge of an unneceſſary quantity; and which, if retained, will ſooner or later produce fatal obſtructions, particularly ſhortneſs of breath and ſuffocations, the conſtant harbingers of death in old age. A juſt ſenſe of theſe, and ſome other ill attendants ſhewn in the preceeding ſections, neceſſarily incident to this laſt period of frail life, has drawn from a *Roman* poet, the following beautiful and exact deſcription (*a*):

Hæ ſunt primitiæ mortis, his partibus ætas
Defluit, & pigris greſſibus ima petit.
Non habitus, non ipſe color, non greſſus euntis,
Non ſpecies eadem, quæ fuit ante, manet.
Contrahimur, miroque modo decreſcimus ipſi:
Diminui noſtri corporis oſſa putes.

(*a*) CORN. GALLUS.

Nec cælum ſpectare licet, ſed prona ſenectus
Terram, a qua genita eſt, & reditura, videt:
Fitque tripes prorſus, quadrupeſque, ut parvulus infans,
Et per ſordentem flebile ſerpit humum.
Ortus cuncta ſuos repetunt, mortemq; requirunt,
Et redit ad nihilum, quod fuit ante nihil.

§ 10. From the conſideration of § 5. Exp. VI. § 5, 6. Exp. VIII. § 5, 6. Exp. X. § 2, 3, 4. Exp. XI. we may be furniſhed with the true reaſon of that well-known maxim in Phyſic, that true original and habitual Conſumptions ſeldom ſpontaneouſly ariſe after a perſon is turned forty. This is generally imputed to the greater ſtrength of the Veſſels, and abundantly confirmed by the preceeding experiments. For though the juices of the body grow naturally more acrid and pungent by their conſtant attrition on each other; yet being daily ſupplied with a conſiderable quantity of freſh and mild chyle, muſt ſuffer a leſs degree of alteration, than the coats of the Arteries, on which the impulſe is perpetually repeated, without any ſuch ſupply, as is ſufficient to preſerve them in a continued equal ſtate; and conſequently the arterial coats will, by this gradual increaſe of ſtrength and firmneſs, prove ſo ſtrong, as not eaſily to be affected by the included fluid, or be ſo readily lacerated by coughing, as to produce a hæmorrhage, or have their coats ſo diſtended, as to produce tubercles and obſtructions in thoſe, as in younger perſons.

There are indeed other reaſons beſides theſe I have enumerated, why Conſumptions ſhould begin before the age above-mentioned, rather than later; but as they flow not from theſe experiments, I ſhall not trouble the reader with them.

EXPERIMENT XII.

§ 1. I took part of the great Artery in a calf, where the radius of its Curvature was the greateſt; and having firſt marked the limits of its moſt Convex ſurface, I divided it lengthways from the oppoſite ſide, which was the Concave ſurface of the ſame Artery; then weighing both in air, I found the weight of the Convex part to be 2 pennyweights, 22 grains, 94 mites; and that of the Concave was 2 pennyweights, 18 grains, 4 mites. I afterwards weighed them in water, and found the firſt to counterpoiſe 4 grains, 38 mites; and the ſecond, when immerſed in the ſame fluid, to weigh 3 grains, 27 mites.

§ 2. Hence it appears, that the Convex ſide of the Aorta in the preceeding calf, was, with reſpect to the denſity, to that of the Concave ſide of the ſame Artery, in the proportion of nearly 82 to 81.

§ 3. After the ſame manner I found the Convex part of the great deſcending Aorta in an old ox, to be in denſity to that of the Concave ſide of the ſame veſſel, nearly as 50 to 49; and the Convex part of the great Artery in a young boar was to that of the Concave in the ſame reſpect, nearly as 78 to 79; laſtly, the analogous parts in a ſix years old ram, and a lamb, bore nearly the proportion of 57 to 56, and 88 to 89 reſpectively.

EXPERIMENT XIII.

§ 1. The thickneſs of the Convex ſide of the Artery taken from the calf, was 0.16 of an inch, and that of the Concave was 0.14. The Convex ſide of the ox's Artery was $\frac{2}{7}$ of an inch thick, and the Concave part of the ſame was $\frac{1}{4}$ of an inch in thickneſs. The Convex part of the Artery in the lamb was $\frac{1}{14}$ of an inch thick, and the Concave part was $\frac{1}{17}$. The thickneſs of the Convex part of the Aorta in the ram was $\frac{1}{9}$ of an inch, and the oppoſite Concave ſide of the Artery was $\frac{1}{11}$.

§ 2. Hence 'tis evident, that the Convex part of the calf's Artery exceeded the other ſide in thickneſs in the proportion of 8 to 7.

§ 3. Hence alſo we learn, that the Convex ſide of the Aorta in the old ox was in thickneſs to that of the oppoſite part of the ſame Artery, as 8 to 5; and the analogous parts in the lamb and the ſheep, bore the ſame proportion in this reſpect to each other; as 17 to 14, for the two different ſides of the ſame Artery in the Lamb; and as 11 to 9, for thoſe in the latter, *viz.* the ſix years old ſheep.

EXPERIMENT XIV.

§ 1. I filled an iron Syphon, that had a free communication with my condenſing Syringe, with a ſufficient quantity of Mercury; into which I ſcrewed a glaſs Gage, above double the length of thoſe commonly uſed, that the different Altitudes of the Mercury in it might be taken with more eaſe, and greater exactneſs. I then took part of the Aorta deſcendens of a young man, whoſe diameter was half an inch, and having firmly fixed it to a Tube iſſuing out of the Syphon, I compreſſed the air in the ſealed top of the Gage, with a force equal to 4.7

Atmoſpheres, with this Preſſure the coats of the Artery burſt.

§ 2. Now the Area of an inch in length of this Artery, being ſo many parts of a ſquare inch, as correſpond to the tabular Logarithm 0.1962947, and the Altitude of the incumbent column of Mercury (taking 29 inches, the mean height of the Quickſilver in the Barometer for the weight of one Atmoſphere) being likewiſe expreſſed by the Logarithm 2.1344959, it is evident, that the preſſure required to break this portion of the Artery, was equivalent to a column of Mercury, having the preceeding Area and Altitude for its baſe and height. Hence a cubic inch of Mercury weighing 7.384 z. troy, its Logarithm is 0.8682917; and conſequently the Logarithm 3.1990823 will expreſs in ounces troy the force the Artery was compreſſed

preſſed with, at the moment of its burſting, which by reduction appears to be equal to 131 pounds, 10 ounces, 0 pennyweight.

EXPERIMENT XV.

§ 1. The Aorta of the ſame man, upon an area of an inch in length, where the diameter was 0.3 of an inch, being tried in the ſame manner as the preceeding veſſel, bore the preſſure of 4.26 Atmoſpheres, ere its Fibres gave admittance for the air to paſs through.

§ 2. Now the area of this Artery an inch in length, being expreſſed by the Logarithm .$\bar{9}$.9745117, it is evident, that the weight of a column of Mercury upon this area, and whoſe Altitude is equal to 4.26 Atmoſpheres, will be expreſſed by the Logarithm 2.9346110; which, by computation from its value in ounces troy, we find equal to 71 pounds, 8 ounces, 4 pennyweights, 14 grains.

§ 3. As the areas of an inch in length of this Artery in the young man, where the diameter was half of an inch, and where it was 0.3 of an inch, are denoted by the Logarithms 0.1962947. $\bar{9}$.9745117 reſpectively; conſequently, by comparing theſe areas with the Logarithms of the weights, that each of them required to burſt their Fibres aſunder, it is evident, that the inferior part of the ſame Artery, upon an equal ſurface with the upper, would not have yielded to the compreſſion, till the weight was equivalent to 119 pounds, 5 ounces, 10 pennyweights.

§ 4. The thickneſs of the Aorta mentioned in the preceeding experiment, was 0.097 of an inch; and that part of it, whoſe ſtrength was found here in this, was 0.049 of an inch. Hence comparing the Logarithms of theſe thickneſſes, *viz.* $\bar{8}.9867717$, $\bar{8}.6901961$ with the Logarithms of the weights ſuſtained upon equal areas of theſe veſſels, as given in the preceeding ſection, it appears that the narrower part of the Aorta deſcendens in this young man differed ſo much in the texture and coheſion of its Fibres from that of the ſame Artery, at a conſiderable diſtance above it, as to render a portion of the former, ſtronger than one of equal bulk of the latter, in the proportion of nearly 1794 ad 1000.

EXPERIMENT XVI.

§ 1. Part of the Aorta deſcendens of a young boar cut off ſome diſtance above the Cœliac branches of the Artery, being fixed to the Condenſer, the air was compreſſed in the top of the Gage with a force equal to 3.58 Atmoſpheres; with this the Artery broke.

§ 2. The diameter of this part of the Artery was 0.27 of an inch, and conſequently its area an inch in length, will be expreſſed in parts of a ſquare inch by the Logarithm $\bar{9}.9294189$. Now the weight of one Atmoſphere upon an inch ſquare being equal to 214.136 ounces troy, it is evident, that the weight of 3.58 Atmoſpheres upon this area of the Artery, will be equal to 54 pounds, 2 ounces, 14 pennyweights, 9 grains.

EXPERIMENT XVII.

§ 1. Part of the ſame Aorta of the young boar cut off nearer the Iliac, than Emulgent branches, bore the preſſure of 3.2 Atmoſpheres, before it was able to break the Artery, or produce any leakage through its coats.

§ 2. The diameter of this part of the Artery was 0.17 of an inch, and conſequently, its area an inch in length will be expreſſed in parts of a ſquare inch by the Logarithm $\bar{9}.7277852$, and the weight of the column of Mercury incumbent on it at the time of its burſting, by the value of the Logarithm 2.5636249 taken in ounces troy, equal, as appears from computation, to 30 pounds, 6 ounces, 2 pennyweights, 9 grains.

§ 3. Comparing the areas of the preceeding veſſels in the Boar together, and likewiſe the weights required to break them, as delivered above (*a*), it will be found, that the inferior part of the Artery between the Emulgent and Iliac branches, upon an area equal

---

(*a*) See § 2. Exp. XVI. and XVII.

to the ſuperior part of the ſame Artery above the Cœliac branch, would have born a weight equal to 48 pounds, 6 ounces, 9 pennyweights.

§ 4. The thickneſs of the Aorta, whoſe ſtrength we found by Exp. XVI. was 0.046 of an inch, and that part of the ſame veſſel made uſe of in this experiment, was 0.024 of an inch. Now the Logarithms of theſe thickneſſes are $\bar{8}.6627578$, $\bar{8}.3802112$ reſpectively, which being compared with the Logarithms of the weights ſuſtained upon equal areas of theſe veſſels, *viz.* with 2.8139936, 2.7652586, it is manifeſt that the Aorta deſcendens of this Boar, at a little diſtance from the Iliac branches, was compoſed of Fibres differing ſo much from the texture and coheſion of thoſe, which compoſed the ſuperior part of the ſame Artery above the Cœliac branches, as to render a portion of this narrower part of the Aorta of equal area and thickneſs with another of the upper, where it was 0.27 in diameter, ſtronger than this laſt, in the proportion of nearly 1713 to 1000.

§ 5. It is evident, from the preceeding experiments that the ſuperior thickneſs of the Aorta at its Curvature is not merely the effect of age, and the repeated ſtrokes of a long-continued circulation, as has frequently been aſſigned for the cauſe of this difference; but that even in young animals, where no ſuch effect can reaſonably be expected, from the duration of the impetus upon this, more than in the oppoſite Concave ſurface of the Artery, we yet find that its Convex ſide, is by nature, formed with a ſuperior degree of denſity and thickneſs,

neſs (*a*). Nor is the reaſon of this contrivance far to ſeek: For ſince that power by which the Arteries contract, is wholly owing to ſome peculiar make and conſtitution of the Fibres which compoſe them, it is evident, that the *momentum* of this contraction muſt, *cæteris paribus*, be always in proportion to the number of Villi, that is, their thickneſs. Now, as we learn from Anatomy that this remarkable Curvature of the Aorta, was highly requiſite for the due conveyance of the blood to the two different extremes of an animal body; and alſo admirably ſerves to a regular and ſufficient ſecretion of the nervous fluid, ſo it is no leſs manifeſt from the laws of Hydraulics, that the blood thrown out at each Syſtole of the heart, muſt im-

---

(*a*) See Exp. XII, XIII.

pinge upon this Convex part of the Artery with its full force; and conſequently, not only a much greater contracting power was neceſſary to prevent the dangers and inconveniences, which would unavoidably ariſe from too great a dilatation of this part; but alſo, that the motion of the propelled fluid, might be communicated to the oppoſite ſide of the ſame Artery, with as little loſs as was poſſible, after its impulſe on a ſurface ſo elaſtic and contractile.

§ 6. Anatomiſts have in general repreſented that force with which the Arteries contract, by the number of circular Fibres lying in parallel directions from the baſe of the Cone to the Apex; and in conformity to this opinion, have ventured to preſume, that as the coats of the Arteries diminiſh in thickneſs at every branching from the trunk, their reſiſting power muſt decreaſe in the ſame ratio, and conſequently be in all caſes proportionable to the circumference of the Artery, and the thickneſs of its coats.

But this concluſion is by no means true, as appears from the preceeding experiments (*a*) which being compared with the former already mentioned in the foregoing ſection, manifeſtly ſhew, that ſuch a general notion in no-wiſe quadrates with the workmanſhip of nature, who is ſo far from obſerving any ſuch law in that complicated ſeries of veſſels, which make up an animal body, that not only the coheſion of the Fibres in different veſſels admit of the greateſt latitude and variety (*b*) but that even the Villi, which compoſe the oppoſite

---

(*a*) § 4. Exp. XV. § 4. Exp. XVII.
(*b*) § 4. Exp. XV. § 4. Exp. XVII.

ſides of the ſame Artery, differ very conſiderably both in their thickneſs and denſity (*a*).

Nor is ſuch a ſtructure of an animal canal any-ways diſagreeable to that preciſe and rigorous exactneſs, which we find in all the works of nature, but was really neceſſary. For ſince the blood is a very heterogeneous fluid, and compounded of particles very different from each other in their relations, and ſpecific gravities, it is evident, that in their motion they will be endowed with very different centrifugal forces, and on that account require a different repelling force, in different parts of the ſame veſſel, both to keep up a due mixture of the fluid, and alſo to propel it into the lateral canals, according to their various An-

---

(*a*) § 2, 3. Exp. XII, XIII.

gles and Curvatures. But even this, in the larger veſſels we find always performed, and no doubt is ſo in the ſmaller, could we equally take a meaſure of their angles, coats, and proportions. Thus we find, that in all thoſe parts of the veſſel, where its Curvature was neceſſary, the Convex ſide of the Artery is much the ſtrongeſt, denſeſt and thickeſt, which was really neceſſary with regard to thoſe particles, whoſe niſus at the tangent is much the ſtrongeſt, which will be carried in greater proportion againſt that ſide of the Artery where it is Convex, and thence be determined into ſuch veſſels and in ſuch proportions, as are requiſite for the performing the various functions for which they are deſigned, whilſt thoſe endowed with a leſs *momentum*, will in a proportional manner be determined by the weak and thinner ſide of the Artery.

Beſides as the blood is an imperfect fluid, and can by no means be brought under the definition of one whoſe parts give way to the leaſt preſſure, but muſt be conſidered as endowed with a conſiderable degree of tenacity and coheſion, and even as borrowing part of its fluidity from its progreſſive motion, therefore many of its particles, would be in a perpetual danger of adhering to the ſides of the membranous canals, through which they paſs, were not their points of contact, as well as their impetus perpetually altered by the various angles and flexures of the containing veſſels; and conſequently neither its due fluidity could have been preſerved, nor the requiſite ſecretions performed, had not the different ſtrength in various parts of the containing veſſels, as well as their different flexures and angles, contributed thereto.

EXPERIMENT XVIII.

§ 1. Part of the Aorta deſcendens of an ewe ſheep near the heart, which weighed in air 2 pennyweights, 18 grains, 60 mites, counterpoiſed in water, 3 grains, 32 mites. The weight of the like veſſel, taken from a ram, was in air 3 pennyweights, 9 grains, 32 mites; and in water 5 grains, 3 mites.

§ 2. The weight of the Vena cava correſponding to the Aorta of the ewe, was in air equal to 1 pennyweight, 12 grains, 38 mites, and in water 2 grains, 98 mites; and the weight in air of that correſponding to the Aorta of the ram, was 2 pennyweights,

weights, 3 grains, 5 mites; and in water 4 grains, 69 mites.

§ 3. Hence it appears, that $\frac{6660}{6328}$ expreſſes the ratio which the Aorta of the ewe ſheep bears to water, and $\frac{8122}{7629}$ denotes that of the other Aorta in the ram to the ſame fluid; conſequently by dividing one ratio by the other, or what is more expeditious and ſufficiently exact, by a ſubtraction of their reſpective Logarithms 0.0222077, 0.0277572, we ſhall obtain the Logarithm of the Quotient, equal to 0.0055495, which ſhews by the number correſponding thereto in the Tables, that the Aorta of the ram was ſuperior in denſity to that of the ewe, in the proportion of 79 to 78 nearly.

§ 4. In like manner we ſhall find that the Logarithm 0.0047594, expreſſes the ratio, which the Vena of the ram bears to that of the ewe; and by comparing it with the number correſponding to it in the Tables, it appears, that the Vena cava in the ram, was with relation to denſity, ſuperior to that of the Vena cava in the ewe, in nearly the proportion of 91 to 90.

EXPERIMENT XIX.

§ 1. Part of the great Artery, cut off at the branching of the Iliacs in the ewe ſheep, mentioned in the preceding experiment, weighed in air 1 pennyweight, 19 grains, 9 mites, and in water 2 grains, 39 mites. Part of the great Artery of the ram, mentioned in the ſame experiment, and cut off at the branching of the Iliac Arteries, weighed in air 2 pennyweights, 7 grains, 4 mites, and the ſame counterpoiſed in water 3 grains, 79 mites.

§ 2. The Venæ cavæ correſponding to the preceeding Arteries of an ewe and a ram, weighed in air 1 pennyweight, 5 grains, 14 mites, and 1 pennyweight, 16 grains, 3 mites; and in water they counterpoiſed 2 grains, 14 mites, 3 grains, 17 mites reſpectively.

§ 3. Hence it appears, that the ratio which the Aorta at the Iliac branches of the ewe ſheep bears to water, is expreſſed by $\frac{4209}{4070}$, and that $\frac{5504}{5125}$ denotes that proportion, which the Aorta of the ram, at the branching of the Iliac Arteries from it, bears alſo to water; hence by a computation in Logarithms, it appears, that the Logarithm of the Quotient, after the diviſion of theſe two ratios, is equal to 0.0062024, which being compared with the number correſponding to it in the Tables, ſhews that the Artery of the ram, at the branching of the

Iliac Arteries, was to the Aorta of an ewe, near its diviſion into the like veſſels with reſpect to denſity, in a proportion ſomewhat greater than that of 71 to 70.

§ 4. Now $\frac{2914}{2700}$, $\frac{4003}{3086}$ reſpectively ſhew the ratio, which the Venæ cavæ in an ewe and a ram bear to the ſame fluid water, and the Quotient after diviſion is equal to the Logarithm 0.0028084; conſequently the number correſponding to this Logarithm, ſhews that the Vena cava of the ram near the Iliac branches, was ſuperior in denſity to the Vena cava of the ewe near the origin of the like veſſels from it, in the proportion of nearly 155 to 154.

§ 5. Comparing the Logarithms which expreſs the ratio's $\frac{6660}{6328}$, $\frac{4309}{4070}$, $\frac{8132}{7629}$, $\frac{5504}{5125}$ in § 3. Exp. XVIII, and § 3. of the preſent experiment together, it appears, that the Aorta of the ewe ſheep, was ſuperior in denſity at the branching of the Iliac veſſels from it, to that part of the ſame veſſel near its exit from the heart, in the proportion of 170 to 169 nearly; and the denſity of the Aorta of the ram near the ſame branches, was ſuperior to that near the heart, in the proportion of 134 to 133 nearly.

§ 6. Comparing alſo the ratio's reſpectively belonging the Veins mentioned in the two preceeding experiments, it appears that the Vena cava of the ewe, is ſuperior in denſity to that Part of the ſame Vein continued to the Iliac branches, in the proportion of 108 to 107 nearly; and the Vena cava of the ram, near its entrance into the heart, is to that part of the ſame Vein near the Iliac branches in the proportion of nearly 73 to 72.

§. 7. Hence it is evident, that altho' the correſponding Arteries and Veins in a ram are denſer than thoſe performing the ſame office in an ewe, yet the principal difference in this reſpect, ſubſiſts between the arterial veſſels of the two animals, the Veins in the ewe being altogether as denſe, or rather more ſo in reſpect of their correſponding Arteries, than the ſimilar Veins in a ram to their reſpective arterial veſſels.

EXPERIMENT XX.

§. 1. Part of the Aorta of a middleſized ram, cut off near the origin of the Emulgent veſſels, being fixed to the Condenſer, the air was compreſſed in the top of the Gage with a force equal to 4,36 Atmoſpheres, before the coats of the Artery yielded to the preſſure.

§ 2. The diameter of this part of the Artery was 0.3 of an inch, and conſequently its area an inch in length will be expreſſed by the Logarithm $\bar{9}$.9745117. Now the preſſure required to break this part of the Aorta, being equivalent to the weight of a column of Mercury, having the preceeding area for its baſe, and its altitude equal to 4.36 Atmoſpheres, it is evident, that the Logarithm 2.9446879 correſponding to 73 pounds, 4 ounces, 8 pennyweights, 5 grains troy, will give the force with which the Artery was compreſſed, and with which its Fibres burſt aſunder.

EXPERIMENT XXI.

§ 1. The Vena cava cut off from the ſame ram, and correſponding to the Artery mentioned in the preceeding experiment, bore the preſſure of

4.84 Atmoſpheres, before it was able to break the Vein, or produce any leakage through its coats.

§ 2. The diameter of this part of the Vein was 0.65 of an inch, and conſequently the Logarithm 0.3102684 anſwering to 2.043 parts of a ſquare inch, will expreſs the area of an inch in length of this Vein. Hence it is evident, that the weight of 4.84 Atmoſpheres upon this area of the Vein will be an equivalent to ſo many ounces troy, as are expreſſed by the Logarithm 3.3258025; which correſponding to 176 pounds, 5 ounces, 8 pennyweights, ſhews that a weight equal to this was requiſite to break the Vein an inch in length.

§ 3. Comparing the areas of this Vein and the preceeding Artery together, and likewiſe the weights required to break them, as they are ſeverally delivered above (*a*), it will be ſound that the Aorta at the branching of its Emulgent Arteries, upon an area equal to that of the Vein correſponding to it in the ſame place, would have required a force equivalent to 158 pounds, 11 ounces, 8 pennyweights, before it would have burſt.

§ 4. Hence it is manifeſt, that the Vena cava of the ram near the Emulgents, was ſuperior in ſtrength to the correſponding Artery acting upon an equal quantity of blood, in the proportion of 1110 to 1000 nearly.

EXPERIMENT XXII.

§ 1. The Aorta of an ewe being cut off at the origin of the Emulgent Arteries, and fixed to the Condenſer, I compreſſed the air in the ſealed top of the Gage, with a force equal to

---

(*a*) See § 2. EXP. XX.

that of 3.52 Atmoſpheres, before I was able to break the coats of this part of the Aorta.

§ 2. The diameter of this Artery immediately above the Emulgent branches, was 0.27 of an inch, therefore an inch in length of its ſurface will be expreſſed by the Logarithm $\bar{9}.9294189$, and the weight incumbent on it from the preſſure of 3.52 Atmoſpheres, will be equivalent to ſo many ounces troy, as correſpond to the tabular Logarithm 2.8066513, that is, to 53 pounds, 4 ounces, 14 pennyweights.

§ 3. Comparing the area of this Aorta of the ewe, with that of the Aorta of the ram, mentioned at § 2. Exp. XX. it will be found that the Aorta of the ewe, upon an equal area with that of the ram, would not have burſt without the weight of 59 pounds, 2 ounces, 15 pennyweights, 19 grains.

§ 4. Hence it is manifeſt, that the Aorta of the ram exceeded the ſtrength of the Aorta of the ewe ſheep, tho' equal in area to the former, in the proportion of 1238 to 1000 nearly.

EXPERIMENT XXIII.

§ 1. Part of the Vena cava, cut off immediately above the Emulgent Veins in the preceeding ewe, did not ſuffer any air to eſcape, till the preſſure, given from the continuance of the condenſation, was equal to 4.15 Atmoſpheres, at which time the Vein burſt.

§ 2. The diameter of this part of the Vein was 0.56 of an inch; hence by comparing the area of this Vein an inch in length, with the area of an inch ſquare, and the weight of a column of Mercury incumbent on that, when the altitude is equal to 4.15 Atmoſpheres, it appears, that the weight ſuſtained by an inch length of the Vein, will amount to 130 pounds, 4 ounces, 0 pennyweight, 4 grains.

§ 3. The weight incumbent on the Vena cava of this ewe, at the inſtant of its breaking, being expreſſed in Logarithms, is 3.1942505; hence comparing it with the Logarithm 2.8066513, correſponding to the weight incumbent on the area of an inch in length of the Aorta, anſwering to this Vein in the ewe; and likewiſe comparing the reſpective areas of this Vein and Artery together, it appears, that the Aorta, upon an area equal to that of its correſponding Vein at the Emulgents, would not have yielded to any weight leſs than that of 110 pounds, 6 ounces, 12 pennyweights.

§ 4. Hence it appears that the Vein was ſuperior to the correſponding Aorta at the Emulgents when compared together in equal areas, in the proportion of 1179 to 1000 nearly.

§ 5. The weight required to break the Vena cava of the ewe ſheep, was 130 pounds, 4 ounces, 0 pennyweight, 4 grains, and that required to break the Vena cava of the ram was (*a*) 176 pounds, 5 ounces, 8 pennyweights; which weights being expreſſed by Logarithms, are equivalent to 3.1942505, 3.3258025. Now it follows from the compariſon of theſe Logarithms with thoſe of the areas 0.2455127, 0.3102684 reſpectively belonging theſe Veins in the ewe and the ram, that to break an equal area of the Vena cava of the ewe with that of the like Vein in the ram, the weight

---

(*a*) See § 2. Exp. XXI.

muſt have been 151 pounds, 4 ounces, 0 pennyweight.

§ 6. Hence it is manifeſt that the Vena cava of the ram was in ſtrength ſuperior to the Vena cava of the ewe, though of equal dimenſions as to ſurface, in the proportion of nearly 1166 to 1000.

EXPERIMENT XXIV.

§ 1. The Aorta of the ram, we mentioned in EXP. XX. being cut off at the Iliac branches, and part of it fixed to the Condenſer, the preſſure required to break the Fibres of the Artery in this part of it, was equal to that of 4.11 Atmoſpheres.

§ 2. The diameter of the Aorta here at the Iliacs was 0.26 of an inch, conſequently the Logarithm 9.9122752, correſponding to 0.8171 parts of a ſquare inch, will give the area of an inch length of this Artery. Now the preſſure being equal to a column of Mercury having the preceeding area for its baſe, and its altitude equal to 119.19 inches, it follows that the weight of this column of Quickſilver will be equal to 59 pounds, 11 ounces, 2 pennyweights, 14 grains.

§ 3. Comparing the Logarithms $\bar{9}.9745117$, $\bar{9}.9122752$, 2.9446879, 2.8568067, which reſpectively ſhew the areas of an inch in length of the Aorta of the ſame ram at the Emulgents, and at the Iliac branches, and the weights incumbent on each of them; it is manifeſt, that the Aorta at the Iliacs upon an area equal to an inch length of the ſame Veſſel at the Emulgents, would not have broke without a preſſure equal to 69 pounds, 1 ounce, 18 pennyweights, 14 grains.

§ 4. Hence alſo it is manifeſt, that the Aorta of this ram at the Emulgents, was with reſpect to ſtrength, ſuperior to a portion of the ſame veſſel at the Iliacs acting upon an equal quantity of blood, in the proportion of 436 to 411; that is, of 106 to 100 nearly.

Experiment XXV.

§ 1. The Iliac branch of the Artery, mentioned in the preceeding experiment, burſt, when the preſſure was equal to 4.04 Atmoſpheres.

§ 2. Now a column of Mercury, whoſe baſe is a ſquare inch, and its height one Atmoſphere, or 29 inches, being equal in value to ſo many ounces troy, as are found by the Tables of Logarithms to correſpond to 2.3306897, it follows by analogy, that as the diameter of this Artery was 0.195 of an inch, therefore the weight of a column of Mercury upon an area of an inch in length, and whoſe Altitude is 4.04 Atmoſpheres, will be expreſſed in the ſame manner by the Logarithm 2.7245316, which correſponding to 44 pounds, 2 ounces, 6 pennyweights, 9 grains, ſhews that this was the weight neceſſary to break an inch in length of this Iliac Artery.

§ 3. Comparing the weights, which the Iliac Artery and the Aorta of the ſame ram immediately above it, and at the Emulgents ſuſtained upon their reſpective areas, as they are given in Exp. XXIV, XX, it is evident, that the Iliac Artery upon an area equal to the trunk it aroſe from, would have required the weight of 58 pounds, 10 ounces, 17 pennyweights, 14 grains, to break it; and 67 pounds, 11 ounces, 16 pennyweights, had its area been equal to that part of the Aorta near the Emulgents.

§ 4. Hence it appears, that taking equal areas of the Aorta from which the Iliac Artery ſprung, and of the Branch, that the former was ſuperior in ſtrength to the latter in the proportion of 1017 to 1000 nearly.

§ 5. Hence alſo it is evident, that the Aorta at the Emulgents, is ſtronger than the Iliac Artery of equal area with it, in the proportion of 1079 to 1000 nearly.

§ 6. It is manifeſt, that whether we conſider the preceeding Veſſels as ſo many Cones or Cylinders of equal Altitudes, their Capacities to each other will be in the ſame ratio as the ſquares of their diameters; hence we find that the capacity of the Aorta of the ram mentioned at § 2. Exp. XX. is to its capacity in that part of it above the Iliacs, mentioned at § 2. Exp. XXIV. in the proportion of 900 to 676, that is, as 133 to 100 nearly. In like manner we ſhall find that the capacity of this laſt Artery, was to that of its Iliac branch, in the proportion of 67600 to 38025, that is as 18 to 10 nearly; and from hence we may obſerve, that the capacity of the Aorta, before the Emulgents ſpring from it, exceeded that of the Iliac Artery in a proportion greater than that of 23 to 10.

Experiment XXVI.

§ 1. The Aorta of the ram, whoſe ſtrength and denſity we found in Exp. XVIII and XX, was in this place, *viz.* above the Emulgent Arteries, equal in thickneſs to 0.052 of an inch, that part of the ſame Artery at the origin of the Iliacs was 0.035

of an inch thick, and the Iliac branch ariſing from it was 0.0254 of an inch in thickneſs.

§ 2. Comparing the thickneſſes of theſe veſſels with their reſpective diameters after the manner of § 2. Exp. XI. as they are given in the preceeding experiments, it appears from computation, that the fluid contained in the cavity of the Aorta at the origin of the Emulgent Arteries, is to the coat that contains it, in the proportion of 1229 to 1000 nearly, and the fluid contained in the cavity of the ſame veſſel at the origin of the Iliacs from it, will be to its coat in the proportion of 1636 to 1000 nearly; laſtly, the fluid within the cavity of the Iliac branch of the Artery, will bear to the coat that contains it, the proportion of 1698 to 1000 nearly.

§ 3. Hence 'tis evident, that the bulk of the ſolids acting upon the blood in that part of the Aorta of the ram abovementioned, at the origin of the Emulgent Arteries, is, to the bulk of thoſe acting upon it at the origin of the Iliac branches, and in the branch itſelf, with reſpect to the quantity of blood contained in equal lengths of theſe veſſels, in a ratio compounded of the direct proportion of the bulk of their coats, and the reciprocal ratio of the quantity of fluid contained in their cavities, that is, as 49494016, 27849384, to 37170000, 20153376 reſpectively; and conſequently the bulk of the ſolids acting upon the blood in that part of the Aorta at the Emulgents, is ſuperior to thoſe acting upon it at the origin of the Iliac branches, in the proportion of 133 to 100 nearly, and of 138 to the ſame quantity nearly, with reſpect to the Iliac branches.

§ 4. The thickneſs of the Aorta of this ram at the origin of the Emulgents, of the Iliacs, and of the Iliac Artery, when expreſſed in Logarithms, will be 8.7160033, 8.5440680, 8.4048337 reſpectively: Hence comparing theſe Logarithms with thoſe expreſſing the weights ſuſtained upon equal areas of theſe veſſels, as they are given above (*a*), it is evident, that the Aorta deſcendens of this ram at the origin of the Iliac Arteries was compoſed of Fibres ſo different in their texture and coheſion to thoſe, which compoſed the ſuperior part of the ſame Artery at the origin of the Emulgents, as to render a portion of this wider part of the Aorta, inferior in ſtrength to one of equal bulk at the origin of

---

(*a*) § 3. Exp. XIV, XXV.

the Iliacs, in the proportion of 1000 to 1112.

§ 5. Thus alſo by a computation made after the ſame manner as the foregoing, it is evident that the texture of the Iliac Artery renders it not only ſtronger than a portion of the trunk it aroſe from, of equal dimenſions in every reſpect with the branch, in the proportion of 1354 to 1000; but even to ſurpaſs the ſtrength of a like equal portion of the Aorta itſelf at the origin of the Emulgents, in a ſtill greater ratio, *viz.* that of 1897 to 1000.

§ 6. That the Aorta, the nearer it approaches the heart, ſhould be leſs denſe (*a*), of a weaker and more eaſily diſtenſible texture than the branches, which immediately ariſe from it (*b*),

---

(*a*) Exp. XVIII, XIX.

(*b*) § 4. Exp. XV, XVII. and § 4, 5. Exp. XXVI.

and yet withal of ſo conſiderable a thickneſs, as that the fluids contained in this primary trunk bear a much leſs proportion to their coat, than thoſe circulating in the branches to their reſpective coats (*a*), are circumſtances not taken notice of by any Anatomiſt that I know of, and plainly ſhew, that the ſtrength of the animal canals is not to be known by their denſity or thickneſs ſolely, but depends on ſome certain ratio compounded of both theſe together, ſuitable to their particular office and deſign. The different ſtructure of the Aorta at the heart, from that part of it at the Iliacs or the Branches there ariſing, abundantly confirm this truth. For had not this veſſel been endued with ſo conſiderable a degree of thickneſs, as to allow its denſity to be diminiſhed

---

(*a*) § 2, 3. Exp. XXVI.

miniſhed in that proportion, which ſeveral of the preceeding experiments ſhew it to be; its ſtrength muſt like that of the other veſſels there mentioned, have been owing more to a cloſeneſs of its texture, than the thickneſs of its coat; but this is a ſtructure, which would by no means have anſwered the ends of animal life, as it is attended with the ill conſequences already enumerated at § 5. Exp. V, XI. *viz.* its too ſoon growing ſo rigid and ſtiff, as not ſufficiently to be diſtended by the force of the heart; whence the animal, tho' young, would be ſubject to many inconveniences conſequent on old age, and have its term of life much ſhortened; inaſmuch as this Artery, from the great impetus of the blood upon it, would in ſuch circumſtances become rigid, ſtiff, and inflexible much ſooner than the reſt, the conſequence of which is an early old age. But though this would inevitably have been the caſe, was the Aorta ſo formed, yet this is not the ſole inconvenience attending too tenſe and rigid a texture of this Artery. For upon every increaſe in the motion or quantity of the blood, or a ſudden rarefaction of the humors, the animal would be in danger of immediate ſuffocation and death, from the great reſiſtance which the blood would meet with, as well as the want of room to receive this increaſed quantity, in a veſſel not capable of a proper and eaſy diſtention.

Now this does not equally hold good in the branches ariſing from it, on account of their increaſed dimenſions in proportion to the trunk from which they ariſe, the capacities of all which, upon every diviſion of the trunk, when taken together, conſtantly exceeding that of the trunk from which they ſpring.

But as this laxity of the Aorta was neceſſary to the health of the animal, and the continuance of its life to its proper period, ſo was that increaſe of ſtrength and denſity, which we have ſhewn at Exp. XIX, XIV and XV, the coats of the branches ariſing immediately out of this trunk are endowed with, no leſs neceſſary, for carrying on the circulation with ſufficient vigour through the ſucceeding minute ramifications, which could ſcarcely have been performed, had not the vibrations been more ſmart and briſk than in the wideſt part of the trunk ; eſpecially if we conſider, not only the great reſiſtance given to the blood at every ramification by the various angles and flexures of the veſſels, but together with this, the diminution of its velocity by the increaſe of cavity in the branches; which is neceſſarily much diminiſhed on this account, as hydroſtatical experiments undeniably aſſure us; and conſequently had not theſe obſtacles been removed by enduing the branches with a greater tenſity, and thereby enabling them to exert a quicker and ſmarter vibration on the incloſed fluids than is produced by the coats of the great Aorta, the circulation could not have been performed with that vigour and advantage as now it is, had it been performed at all.

This is ſtill more apparent, if we conſider, that this increaſe of the cavity of the branches was indiſpenſably neceſſary both to the life and ſtructure of the animal. For had their united ſum been leſs than in the trunk, or only equal to it at every ſubdiviſion, the progreſs of the fluids muſt ſoon have been obſtructed, ſince as the caſe now ſtands, where the ratio is increaſed, the capillary Arteries are only ſufficient to tranſmit the blood in ſingle Globules, as good Microſcopes aſſure us, and conſequently had the caſe been otherwiſe, the paſſage through them would have been wholly obſtructed, long before the ramifications had been ſo numerous, as at preſent they are. Wherefore had the ſize of the animal been the ſame as now, the conſequence muſt have been, either a total obſtruction as above, or fewer ramifications, the former every one knows is inconſiſtent with life; and had the latter prevailed, the creature muſt have been extremely weak and languid, through the want of ſufficient nouriſhment to warm and invigorate its parts, and enable it to perform the functions for which it was deſigned, even though we ſhould ſuppoſe the ſecretions regularly performed, which in fewer ramifications can ſcarcely be ſuppoſed poſſible, at leaſt in that perfection the preſent ſtructure allows.

EXPERIMENT XXVII.

§ 1. The Vena cava cut off at the Iliacs of the ram, and correſponding to the Aorta mentioned in EXP. XXIV. required the force of 4.33 Atmoſpheres, which it endured without any viſible leakage of air, till the rupture was effected by the foregoing preſſure.

§ 2. The diameter of this part of the Vein was 0.36 of an inch, and conſequently its area an inch in length will be expreſſed by the Logarithm 0.0534626, correſponding to 1.131

parts of a ſquare inch. The weight therefore incumbent on this area of the Vein, will be equal to that of a column of Mercury upon this baſe, and whoſe altitude is 4.33 Atmoſpheres, proceeding therefore with the reſpective Logarithms of theſe quantities, and of a cubic inch of Mercury(*a*), it appears, that 3.0206402 will be the Logarithm, which expreſſes the weight required, which correſponding to 87 pounds, 4 ounces, 14 pennyweights, ſhews us, that this was the force made uſe of to break the Vein in this experiment.

§ 3. Comparing the weights and areas which belong this Vein and its reſpective Artery as they are given above (*b*), it is evident, that the Artery upon an area equal to this here

---

(*a*) § 2. Exp. XIV.

(*b*) § 2. Exp. XXIV.

of its correſponding Vein, would have required the additional weight of 23 pounds, 0 ounces, 5 pennyweights, 5 grains to break it.

§ 4. Hence it appears, that the Vein correſponding to the Aorta at the Iliacs in the ram, was ſuperior in ſtrength to the Artery there of equal area, in nearly the proportion of 1053 to 1000.

§ 5. The weight required to break an inch in length of the Vena cava of this ram near the Emulgent branches, was 176 pounds, 5 ounces, 8 pennyweights; hence comparing the weight, which broke the ſame Vein an inch in length at the Iliacs, with this, and their reſpective area's together, it appears, that the Vein at the branching of the Iliac veſſels, would, upon an area equal to an inch in length of the ſame Vein at the Emulgents, not have burſt, unleſs

leſs the weight had been equivalent to 157 pounds, 10 ounces, 6 pennyweights.

§ 6. Hence it is evident, that the Vein correſponding to the Artery at the Iliac branches was inferior in point of ſtrength to that part of it correſponding to the Artery at the Emulgents, though of equal area with this laſt, in the proportion of 1000 to 1117 nearly.

EXPERIMENT XXVIII.

§ 1. The Iliac Vein of the preceeding ram correſponding to the Artery in EXP. XXV, being tried in the ſame manner as the trunk in the preceeding experiment, bore without ſuffering any air to eſcape, till the rupture of its coats enſued, the preſſure of 4.18 Atmoſpheres.

§ 2. The diameter of this Vein was 0.25 of an inch, and conſequently the

Logarithm of its area an inch in length will be equal to $\bar{9}.8952567$, hence eſtimating the weight of a column of Mercury upon this area, whoſe altitude is equal to 4.18 Atmoſpheres; it appears, that the preſſure incumbent on the Vein at the inſtant of its breaking was 58 pounds, 7 ounces, 5 pennyweights, 9 grains.

§ 3. The Logarithm of this weight, ſufficient to break an inch in length of this Iliac Vein, being 2.8471227, it is evident from the compariſon of this Logarithm with the Logarithm 3.0206402, which denotes the weight required to break an inch in length of the trunk, together with a compariſon of the Logarithms of their reſpective areas, that the Iliac Vein, upon an area equal to an inch in length of its trunk, would have required the weight of 84 pounds, 4 ounces, 8 pennyweights to break it.

§ 4.

§ 4. Hence it appears, that the Iliac Vein of equal area to the trunk, was exceeded in ſtrength by that, in the proportion of 1036 to 1000 nearly.

§ 5. The diameter of the Iliac Artery correſponding to the preceeding Vein was 0.195 of an inch (*a*), therefore the Logarithm of its area an inch in length will be $\bar{9}$.7874605, and the Logarithm of the weight required to break this area was 2.7245316: Hence comparing theſe Logarithms with thoſe reſpectively belonging the Vein as given in § 2, 3. of this expement, it appears, that had the area of the Iliac Artery been equal to this of its correſponding Vein, the weight required to break it muſt have been equal to 56 pounds, 7 ounces, 14 pennyweights, 4 grains.

(*a*) § 2. Exp. XXV.

§ 6. It appears therefore, that the Iliac Vein was ſuperior with reſpect to ſtrength to the correſponding Artery acting upon an equal quantity of blood as 1034 to 1000 nearly.

§ 7. In comparing the areas of the Veins correſponding to the preceeding Arteries in a ram at Exp. XX, XXIV and XXV, it is evident, that the capacity of the Vena cava at the Emulgents, is to that of the Aorta above its Emulgent branches in the proportion of 4225 to 900, that is, in a proportion of 4694 to 1000 nearly; and the capacity of the Vein at the Iliac branches, is to that of the correſponding Artery, in the proportion of 1296 to 676, that is, of 191 to 100 nearly; and the capacity of the Iliac Vein exceeds the capacity of an equal length of the Iliac Artery, in the proportion of 62500 to 38025, that is, as 164 to 100 nearly.

§ 8. In comparing the capacities of the Veins and correſponding Arteries together in equal lengths, it is evident, that the capacity of the Vena cava above the Emulgents, with reſpect to the capacity of the Vein at the Iliacs, is to the capacity of the Aorta at the origin of the Emulgents, with reſpect to the capacity of the Aorta at the origin of the Iliacs, in the proportion compounded of the direct ratio of the capacities of the Veins, and the reciprocal one of the Arteries, that is, in the proportion of 28561 to 11664, or nearly as 245 to 100; and conſequently the Vena cava at the Emulgents, exceeds with reſpect to capacity that of an equal length of the Vein above the Iliacs, in the proportion of 326 to 100 nearly. In like manner it is evident, that the capacity of the Vein above the Iliac branches, with reſpect to the capacity of an equal length of the branch diſcharging itſelf into it, is ſuperior to the capacity of the correſponding Aorta, with reſpect to the capacity of an equal length of the branch ariſing thence in the ratio of 492804 to 422500, that is, in the proportion of 116 to 100 nearly; and from hence alſo it appears, that the capacity of the Vein above the Iliac branches, was to that of the branch of an equal length to it, in the proportion of 2073 to 1000 nearly.

§ 9. This extraordinary capacity of the Vena cava in this part above the origin of the Emulgents, in proportion to the correſponding Artery, is of ſingular ſervice to the animal; as a reſervoir to ſupply the heart immediately with a ſufficient quantity of blood;

upon great and ſudden evacuations, or even upon ſmaller, where the animal labours under any remarkable weakneſs of body; on defect of which it would frequently faint, and ſometimes exſpire: the blood, though in ſufficient quantity in the parts more remote, being incapable of ſupplying the heart with its due quantity on ſuch ſudden emergencies. But beſides this advantage accruing to the animal, from the formation of this part of the Vena cava, according to the preceeding ſection; its enlarged capacity ſeems alſo neceſſary here, in order to receive that large quantity of blood, which muſt be diſcharged into it from the lower belly, upon ſtrong ſtraining of the body, in exerting its ſtrength upon innumerable occaſions; which as it cannot be performed, without a large diſcharge of the venal blood into this Veſſel, the Abdomen being ſtraitned by the depreſſion of the Diaphragm, the Heart in ſuch circumſtances, muſt have been frequently ſurcharged with ſo great a quantity of blood, as would have prevented its acting with that freedom it now does, had not this Vein been formed more large and capacious, with reſpect to its correſponding Artery, than they generally are. This we ſee happens upon great plenitude in Fevers even as the caſe now ſtands, and is relieved by bleeding, the vigour of the pulſe being thereby increaſed in this caſe, as it is diminiſhed in others. What then muſt have been the conſequence, had the contrary ſtructure prevailed, or even leſs room had been given, I have no occaſion to explain?

EXPERIMENT XXIX.

§ 1. The Aorta of the ewe ſheep mentioned in Exp. XXII, being cut off immediately above the Iliac branches, and fixed to the Condenſer, the preſſure given it before any rupture could be made in its coats, was equal to 3.23 Atmoſpheres.

§ 2. The diameter of this part of the Aorta was 0.246 of an inch. Hence by comparing the area of this Vein an inch in length, with the area of an inch ſquare, and the weight of a column of Mercury incumbent on it, when the altitude is equivalent to the preſſure of 3.23 Atmoſpheres, it appears, that the area of an inch in length of this Artery, was preſſed, at the inſtant of its breaking, with the weight of 44 pounds, 6 ounces, 14 pennyweights, 9 grains.

§ 3. The weight which preſſed upon a ſimilar part of the Aorta of the ram was 59 pounds, 11 ounces, 2 pennyweights, 14 grains (*a*). Now the Logarithm $\bar{9}.9122752$ expreſſes the area of an inch in length of the Aorta of the ram, and $\bar{9}.8882357$ expreſſes in like manner the area of the Aorta of the ewe; hence comparing theſe weights and their reſpective areas together, it is evident, that the Aorta of the ewe above the Iliac branches would have required, had its area been equal to that of the Aorta of the ram in the ſame circumſtances, the preſſure of a weight equivalent to 47 pounds, 1 ounce, 3 pennyweights, 9 grains.

§ 4. Hence it appears, that the Aorta of the ram above the Iliac branches was ſuperior to a portion of the Aorta of the ewe above the ſame branches

---

(*a*) § 2. Exp. XXIV.

acting on an equal quantity of blood, with reſpect to ſtrength, in the proportion of 1272 to 1000 nearly.

§ 5. Comparing in like manner the weights and areas, which preſſed upon the Aorta of this ewe, at the origin of the Emulgent veſſels and of the Iliacs, as they are given in this Experiment and EXP. XXII, it appears, that the Aorta of the ewe would upon an equal area of the Iliacs with that of the ſame veſſel at the Emulgents, have required the weight of 48 pounds, 11 ounces, 18 pennyweights, 4 grains, to break it.

§ 6. Hence it is manifeſt, that the Aorta at the Emulgents was ſuperior with reſpect to the ſtrength of an equal area of the ſame Artery at the Iliacs in this ewe, in the proportion of 1089 to 1000 nearly.

EXPERIMENT XXX.

§ 1. The Iliac branch being cut off from the preceeding Aorta of the ewe, and fixed to the Condenſer, the preſſure required to break it was equal to 3.12 Atmoſpheres.

§ 2. The diameter of this branch was 0.19 of an inch, and conſequently the area of an inch in length of this Artery, will be expreſſed by the Logarithm $\bar{9}.7759743$, correſponding to 0.5971 parts of a ſquare inch; now a column of Mercury whoſe baſe is a ſquare inch, and its height one Atmoſphere, or 29 inches, being equal in value to ſo many ounces troy as correſpond to the Logarithm 2.3306897, it is evident, that the weight upon the preceeding area from the preſſure of 3.12 Atmoſpheres, will be expreſſed in like manner by the Logarithm 2.6008186;

2.6008186; which correſponds by the Tables to 33 pounds, 2 ounces, 17 pennyweights, and is equal to that incumbent on an inch length of the Iliac Artery when it broke.

§ 3. The area of an inch in length of the trunk of this Artery, being compared with the area of an inch in length of the branch, and likewiſe the weights which were requiſite to break thoſe areas reſpectively, as they are mentioned in this and the foregoing experiment, it is manifeſt, that the branch would, upon an equal area to its trunk, not have broke, unleſs the weight had been equal to 43 pounds, 0 ounces, 10 pennyweights, 9 grains.

§ 4. Hence it appears, that the trunk of the Aorta at the Iliacs in this ewe, was ſuperior to the ſtrength of the branch acting upon an equal quantity of blood, in the proportion of 1035 to 1000 nearly.

§ 5. The weight which preſſed upon an area of an inch in length of the Iliac Artery of the ram was 44 pounds, 2 ounces, 6 pennyweights, 9 grains: Hence comparing this weight and area with thoſe reſpectively belonging the Iliac Artery of the ewe in this experiment, it is evident, that the Iliac Artery of the ewe, had its area been equal to that of the ſame Artery in a ram, would have required the weight of 34 pounds, 1 ounce, 11 pennyweights to break it.

§ 6. Hence it appears, that an equal portion of the Iliac Artery as to ſurface, in the ram, was ſuperior with reſpect to ſtrength, to the like Artery in an ewe, in the proportion of 1295 to 1000 nearly.

§ 7. It appears from § 2. Exp. XX, § 3. Exp. XXV, § 2. Exp. XII, and XXX, that the weights required to break an equal portion of the Aorta at the Emulgents and of the Iliac Artery in the ram are 73 pounds, 4 ounces, 8 pennyweights, 5 grains, and 67 pounds, 11 ounces, 16 pennyweights reſpectively; and from the compariſon of the weights and areas reſpectively belonging the analogous veſſels in an ewe, it appears, that the weights required to break equal portions of theſe veſſels are 53 pounds, 4 ounces, 14 pennyweights, and 47 pounds, 3 ounces, 17 pennyweights, 19 grains reſpectively; therefore the ſtrength of the Iliac Artery of the ram with reſpect to an equal portion of the great Artery at the Emulgents, was ſuperior to the ſtrength of the Iliac Artery of the ewe, with reſpect to its

Aorta at the Emulgents, in equal areas to the former veſſels in the ram, in a proportion compounded of the ratio of the weights, which belong the preceeding veſſels in a ram, and of the ratio of the weights belonging the correſponding veſſels in an ewe, which proportion appears from computation, to be that of 1046 to 1000 nearly.

§ 8. In comparing the areas of the preceeding Arteries together in equal lengths, it is manifeſt from § 2. Exp. XX, XII, XXIV, XV, XIX, and XXX, that the capacity of the trunk of the Aorta above the Iliac branches, and of the branch itſelf in an ewe, with reſpect to the capacity of the Aorta of the ſame animal above the Emulgents, is to the capacity of the correſponding veſſels in a ram, with reſpect to that of their reſpective trunk at the Emulgents, in a proportion compounded of the ratio of the capacities of the Aortas at the Iliacs, and of the branches directly, and of the ratio of the capacities of the reſpective Aortas at the Emulgents inverſely; that is, as 544644, 32490000, to 492804, 27720225 reſpectively; and conſequently the capacity of the deſcending trunk of the Aorta at the Iliac branches, and of the branch itſelf, with reſpect to the capacity of an equal length of the ſame trunk above the Emulgent branches in an ewe, are ſuperior to the capacities of equal lengths of the veſſels performing the ſame office in a ram, with reſpect to their trunk above the Emulgent branches, in the proportion of 1105 to 1000, and of 117 to 100 nearly for the capacity of theſe different veſſels in an ewe and a ram reſpectively.

§ 9. That the deſcending Aorta below the Emulgents, as well as the branches ariſing from it, ſhould not only be larger in the female than the male, with reſpect to the quantity of blood thrown into each of them, at every ſyſtole of the heart in the two animals (*a*); but even larger alſo, in proportion to the ſuperior part of the Aorta, in the firſt of theſe the ewe, than in the ram (*b*); will be ſufficiently obvious to any, who conſiders the quantity of blood neceſſary for the nutrition of the fœtus. But the reaſon why the coats of theſe veſſels, which as well as ſome others of that animal are found by the preceeding Experiments, to be in general weaker than the ſame in a ram, ſhould ſtill

---

(*a*) Compare § 2. Exp. XXVI. with § 8. Exp. XXX.

(*b*) See preceeding § 8.

be comparatively weaker than thoſe in a male, with relation to the reſpective Aorta of each animal, and the quantity of fluids they derive from thence, as we learn from § 7. of this Experiment they are, is not ſo eaſily aſſigned. Poſſibly the weak ſtate of the Embryo in the beginning of pregnancy, may require that the blood be puſhed with leſs force in theſe veſſels than elſewhere, which yet were neceſſary to be ſo large, in order to ſupply it with a ſufficient quantity of nouriſhment, as it increaſed in ſize, and approached nearer to maturity. Nor perhaps may this weakneſs in the veſſels be leſs neceſſary upon its increaſe in bulk, leſt upon any greater motion of the animal than ordinary, too great an energy in the veſſels, joined with the increaſed motion of the fluids, ſhould by increaſing the

vibra-

vibrations of the ſolids to an extraordinary pitch, occaſion its excluſion before its proper period, as we find familiar to moſt animals upon great and vigorous motion of the body, a febrile diſpoſition, and the like.

But it may poſſibly be objected with regard to human bodies, that none are ſo ſubject to accidents of this nature, as thoſe women, which are troubled with weak nerves and hyſteric diſorders, whoſe Fibres and Veſſels are known to be of a more lax and delicate texture than others. But this ariſes not from the natural ſtructure and make of the Veſſels, for all then would be ſubject to them, as they are to the menſtrual flux, which ariſes from a cauſe not much unlike this in the veſſels of the Uterus (*a*); but from too great Plenitude, high Diet, and the neglect

---

(*a*) *Freind's* Emmenologia.

neglect of ſuch Exerciſe, as is neceſſary to preſerve the natural tone of the Fibres, and a due and equable ſecretion of the neceſſary fluids. On defect of which, the ſpirits are tumultuouſly determined into ſuch parts, as are ever ſo little varied from their uſual ſtate of eaſe and quiet; and conſequently during pregnancy into the muſcles of the Abdomen more copiouſly than the reſt; whence Contraction, Pain, and Abortion muſt frequently enſue. Nor will the acrimony of the juices prove of better conſequence, by diſſolving the Humors, and ſtimulating the Fibres to more frequent Vibrations, and thereby giving occaſion to Pains and Hæmorrhages from the uterine veſſels. But theſe ſymptoms are the effects, not of a natural, but a morbid diſpoſition of the veſſels and humors, and conſequently an objection of this kind has no place here, where the natural ſtructure of the veſſels, and a due diſpoſition of the humors are preſuppoſed.

EXPERIMENT XXXI.

§ 1. The Iliac Vein correſponding to the Artery of the ewe in the preceeding Experiment, bore the preſſure of 3.36 Atmoſpheres, before it was able to break the Vein, or produce any leakage thro' its coats.

§ 2. Now the preſſure of 3.36 Atmoſpheres upon an inch in length of this Vein, will be equivalent to the weight of a column of Quickſilver upon this area, whoſe Altitude is equal to 97.44 inches in height, which being equal to the Logarithm 1.9887373, and its area to the correſponding Logarithm 9.8591383 the weight of 3.36 Atmoſpheres upon an inch in length of this Vein, will amount to 43 pounds, 4 ounces, 3 pennyweights, 19 grains.

§ 3. Comparing the Logarithms $\bar{9}.7759743$, $\bar{9}.8591383$, 2.6008186, 2.7161673, which denote the areas of an inch in length of the Artery and Vein correſponding thereto in the preceeding Experiments, and the weights incumbent on them reſpectively, it appears, that the Artery, had its area been equal to that of the Vein, would not have burſt, unleſs the preſſure had been equivalent to 40 pounds, 3 ounces, 0 pennyweight, 19 grains.

§ 4. Hence it appears, that the ſolids acting upon the blood contained in the cavity of the Iliac Vein of this ewe, were ſuperior in ſtrength to thoſe of the correſponding Artery acting upon an equal quantity of the ſame fluid, in the proportion of 1077 to 1000 nearly.

§ 5. Hence it is evident, that the Vena cava and Iliac Vein in this ewe, with relation to their correſponding Arteries in Exp. XXII and XXX, are ſuperior with reſpect to ſtrength to the ſame Veins in a ram, with reference to the ſtrength of their correſponding Arteries in Exp. XX and XXV, in equal areas to the former veſſels in an ewe, in a proportion compounded of the direct ratio of the preſſures incumbent on the areas of the Veins in each animal at the moment of their burſting, and of the reciprocal ratio of the forces required to break the correſponding Arteries; that is, in the proportion, as appears from computation, of 180940 to 170368, and of 135744 to 130416, which ratios are nearly as 1062, and 1040 to 1000 reſpectively.

EXPERIMENT XXXII.

§ 1. The Aorta of the ewe was, in that part of it above the Emulgents, equal in thickneſs to 0.044 of an inch, and in that part above the Iliacs, and of the branch ariſing from it, the thickneſs was equal to 0.031, 0.023 of an inch reſpectively: The Vena cava of the ram and of the ewe above the Emulgents mentioned in EXP. XXI and XXIII, was 0.034, 0.028 of an inch thick reſpectively, and the Iliac Veins in the ſame mentioned in EXP. XXVIII, XXXI, were 0.014 and 0.011 of an inch reſpectively in thickneſs.

§ 2. Comparing the thickneſſes of theſe Arteries in the ewe with their reſpective diameters, as they are given in the preceeding Experiments, and afterwards the proportions which the coats of theſe Arteries bear to the fluid contained in their reſpective cavities with the proportions delivered at § 2. Exp. XXVI, it is manifeſt, that the coat of the Aorta of the ram above the Emulgents, with reſpect to the blood contained in its cavity, is ſuperior in bulk to the coat of the correſponding Artery in an ewe, with reſpect to the fluid it contains in an equal length of theſe veſſels, in the proportion of 1319 to 1229 nearly. In like manner it appears, that taking equal lengths of the Aorta above the Iliacs, and of the branch, in the ram and the ewe, the coats of thoſe in the firſt of theſe, with reſpect to the fluid contained in their cavities, are ſuperior in bulk to the coats of the correſponding veſſels in the latter, *viz.* the ewe, with relation to the quantity of fluid they act upon, in the proportion of 1762, 1842 to 1636, 1698 reſpectively.

§ 3. Hence it appears, that the Vein above the Emulgents in the ram and in the ewe, which in the firſt was compreſſed with a force equivalent to 176 pounds, 5 ounces, 8 pennyweights, and in the ſecond with 130 pounds, 4 ounces, 0 pennyweight, 4 grains, was nevertheleſs exceeded in thickneſs by the correſponding Aorta of each animal, which upon an equal area would not have burſt, unleſs the weight upon that in the ram had been 158 pounds, 11 ounces, 8 pennyweights, and upon the Aorta in the ewe 110 pounds, 6 ounces, 12 pennyweights, in the proportion of 26,11 to 17 and 7 reſpectively. In like manner we ſhall find that the Iliac Artery in the ram, which upon an equal area with the correſponding Vein bore leſs than it by the weight of 1 pound, 11 ounces, 11 pennyweights, 5 grains, was yet ſuperior in thickneſs in the proportion of 127 to 70; laſtly, tho' the ſtrength of the Iliac Vein in the ewe was inferior to that of an equal area of the Aorta at the Emulgents of the ſame animal by ſcarcely $\frac{1}{21}$ part, yet the Artery was ſuperior in thickneſs to this Vein in the proportion of 4 to 1.

§ 4. Hence we may obſerve, that the Anatomiſts are no leſs miſtaken in their concluſions on the ſtrength of the Veins, than they were, as has been already ſhewn, in their ſentiments on that of the Arteries (*a*). Nor can they ever expect to avoid miſtakes of this kind, whilſt they ſuffer themſelves to be led by appearance, and not by experiment, without which it is impoſſible to arrive at any tolerable degree of certainty in phyſical inquiries. For as a great modern Philoſopher has al-

---

(*a*) § 5, 6. Exp. XVII. § 4, 5, 6. Exp. XXVI.

ready obſerved, "All the real true
"Knowledge we have of Nature is
"intirely Experimental, inſomuch
"that how ſtrange ſoever the Aſſer-
"tion ſeems, we may lay this down
"as the firſt fundamental unerring
"Rule in Phyſics, That it is not
"within the Compaſs of human Un-
"derſtanding to aſſign a purely ſpe-
"culative Reaſon for any one Phæno-
"menon in Nature."

§ 5. Comparing the thickneſſes of the preceeding Arteries in the ewe, with their reſpective diameters, as they are given in this and the preceeding Experiments, it is evident, that the bulk of the ſolids acting upon the blood in that part of the Aorta of this ewe above the Emulgents, are to thoſe acting upon it at the origin of the Iliac branches, and in the branch itſelf, with reſpect to the fluid contained in equal lengths of theſe veſſels, in a ratio compounded of the proportion of the bulk of their coats directly, and the ratio of the quantity of fluid they contain inverſely. Comparing therefore theſe proportions with thoſe in § 3. Exp. XXVI, it is evident, that the bulk of the ſolids, in proportion to the blood contained in the cavity of the Aorta above the Iliacs, and in the Iliac branch, with reſpect to the bulk of an equal length of the Aorta in proportion to the quantity of fluid acted upon by the coat of this Artery above the Emulgents in the ram, is to the bulk of the correſponding veſſels with reſpect to the bulk of the Aorta above the Emulgents in an ewe, and the quantity of fluid contained in each of theſe veſſels, in a proportion compounded of the ratio of the bulk of the ſolids in the Aorta above the Iliacs, and in the branches of each animal directly, and of the reciprocal ratio of the bulk of the ſolids in the Aorta above the Emulgents in the ſame reſpectively. Hence it appears by the computation, that the bulk of theſe veſſels in the ram are ſuperior to that of the correſponding ones in an ewe, when compared together, with relation to the fluid they act upon, and their reſpective trunks above the Emulgent veſſels in the proportion of 124309720846080 0 to 12393149164830 72, and of 401884597442304 to 397713360185856, that is, nearly as 1003 to 1000, and 10104 to 10000 reſpectively.

§ 6. Hence we may obſerve, that notwithſtanding the coats of the veſſels in an ewe, and particularly thoſe mentioned in the preceeding ſection, bear a leſs proportion to the fluid they contain, than the correſponding ones in a ram, as has been already ſhewn at § 2, yet it is equally certain from the foregoing ſection, that even the bulk of the coats of theſe veſſels in the ewe, with relation to the bulk of the principal trunk above the Emulgents, and the quantity of blood contained in each, bear nearly the ſame proportion as thoſe performing the ſame office in a ram, when compared together in the ſame manner; and conſequently the comparative weakneſs of theſe veſſels here in the deſcending part of the Aorta of the ewe, with reſpect to thoſe in the ram, as has already been ſhewn at § 7. Exp. XXX, can ſcarcely be aſcribed at leaſt but in an inferior degree to the difference ariſing from the bulk of theſe coats in the ewe, and their bearing in this reſpect a leſs proportion to the original trunk they are derived from than that which the correſponding ones in a ram bear to their primary trunk, but muſt chiefly ariſe from the different texture of theſe veſſels; which contrivance of diminiſhing their ſtrength without leſſening their relative bulk, was neceſſary for preſerving a ſufficient thickneſs in the arterial coats at every diviſion, which otherwiſe muſt either have been too weak or too narrow for the purpoſe deſigned, or ſubdivided into fewer ramifications than were neceſſary to the well-being of the animal.

§ 7. It is evident from § 4. Exp. XXII, XXIX. § 6. Exp. XXX. § 1, 2. Exp. XXVI, XXXII, that the fabrick of the ram, with regard to its ſolids, muſt be much ſtronger than that of the ewe, which probably is the caſe of all male animals with regard to females of the ſame ſpecies, whoſe Fibres and Veſſels, *cæteris paribus*, are by common obſervation found to be more lax and yielding than thoſe of the former. This is not only confirmed by the preceeding ſections, where their different ſtrength and thickneſſes are examined in various veſſels, but likewiſe from their greater denſity ſhewn at § 3, 4. Exp. XVIII, XIX, which neceſſarily infers the texture of the Fibres themſelves to be more firm and compact, as well as more cloſely wrought together in the coats of the veſſels, otherwiſe the air would not be equally retained in theſe as the former, the reverſe of which appears by experiment.

§ 8. It were eaſy hence to ſhew, that many diſeaſes to which the female ſex are more peculiarly ſubject than the male, are neceſſarily dependent on this particular ſtructure, and *vice verſa*, why thoſe ariſing from too great tenſity and rigidity of the veſſels ſhould be more incident to males, as alſo why too great ſtrength in the one ſhould in many caſes prove as deſtructive, as the natural weakneſs in the other. But this would be launching out too far for the brevity of this Eſſay; which is deſigned rather to ſhew which way more certain data may be procured for explaining the animal œconomy, than have hitherto been uſed, than making haſty deductions; an error already too deeply rooted in the theory of Phyſic.

§ 9. It appears from the computation made after the manner of § 2. Exp. XI, that the fluid contained in the cavity of the Aorta of the ewe at the origin of the Emulgent veſſels, of the Iliacs, and in the branch, bore to their containing coats the proportion of nearly 1319, 1762, 1842 to 1000 reſpectively. Let now the diameter of this Aorta be from any cauſe increaſed only the $\frac{5}{100}$ of an inch, and as the areas of the veſſels continually increaſe at every diviſion of the trunk, let the preceeding proportion with reſpect to the diameter of this become ſmaller in the branches, and decreaſe even with relation to the diameters of theſe veſſels; as for inſtance, let the ratio of increaſe in the two laſt Arteries above-mentioned be 0.045, 0.034 reſpectively, then it is evident that if to the ſquare of the diameters thus increaſed, *viz.* 0.1024, 0.08468I, 0.050176, we add the ſpace included between the outward and inward coat of each Artery, then 0.157664, 0.119029, 0.069772 inch, is the ſquare of their reſpective diameters from outſide to outſide, and conſequently the thickneſſes of theſe Arteries will now be nearly as 0.0385, 0.027, 0.02 reſpectively of an inch, and the proportion which the fluid contained in the cavity of each will bear to their reſpective coats will be that of 1853, 2465, 2560 to 1000 nearly.

§ 10. It is evident from § 2. Exp. XXII, XXIX, and XXX, that the weights, incumbent on an inch in length of the Arteries above-mentioned in the preceeding ſection, at the inſtant of their breaking, were 53 pounds, 4 ounces, 14 pennyweights, 44 pounds, 6 ounces, 14 pennyweights, 9 grains, 33 pounds, 2 ounces, 17 pennyweights, 0 grains. If now we conceive theſe Arteries reduced to the thickneſs as given for each in the preceeding ſection, then it is evident, by taking their value in Logarithms, and comparing theſe and the Logarithms of their former thickneſſes with the Logarithms of the weights abovementioned, that the weight neceſſary to break them in this ſtate would be 46 pounds, 8 ounces, 12 pennyweights, 38 pounds, 9 ounces, 14 pennyweights, 14 grains, 28 pounds, 10 ounces, 16 pennyweights, 19 grains reſpectively.

§ 11. The ingenious Dr. *Hales*, in his concluſions from Exp. 22d, takes notice of the vaſt ſtrength of the animal veſſels in proportion to the action of the fluids upon them, which had it been leſs, would have rendered the animal ſubject to many inconveniences, particularly on great and continued action of the muſcles, the increaſed force of the circulation in ſuch diſeaſes as are capable of making any conſiderable diſtention of the veſſels, and the like. That this muſt frequently have been the caſe, appears very plain from the conſideration of the two preceeding ſections, where it is ſhewn that by a ſmall increaſe of the diameter of the Aorta, the preſſure of the fluids with reſpect to the ſolids is conſiderably increaſed, at the ſame time that their thickneſs and ſtrength are both diminiſhed; and conſequently had the veſſels been endowed with no more ſtrength than was neceſſary for the circulation in an healthful ſtate, they muſt have wanted that elaſticity, which in moſt caſes is abſolutely neceſſary for the diſcharge of ſuch peccant matter, as either partially or totally obſtructs theſe fine canals. This evidently appears from ſuch diſeaſes as are accompanied with too great a laxity of the Fibres, which as Phyſicians well know, are of all others moſt difficultly relieved, thro' the quantity and tenacity of ſlimy and viſcid humors which ariſe from this very cauſe, and ſo clog the Fibres in exerting their natural vibrations, as to render the beſt medicines wholly ineffectual. Not to mention the innumerable tumors, preternatural diſtentions, and ruptures of the veſſels, many of which muſt have either proved preſently mortal, or a laſting inconvenience to the animal. This we know is the neceſſary conſequence of an univerſal weakneſs in the ſolids, and ſuch at leaſt muſt have been the conſequence, had their ſtrength been much leſs in proportion to the force of the fluids than nature has allotted, ſince where this is only little below its proper ſtandard, tho' their force continues vaſtly ſuperior to the impetus of the fluids upon them, ſo great a weakneſs ſucceeds, as renders the party ſubject to many diſeaſes, from which they whoſe Fibres are more tenſe and ſtrong, are wholly exempt.

I might eaſily here alſo ſhew, how uſeleſs ſuch an animal would be both to its ſelf and others, inaſmuch as it could ſcarcely bear the lighteſt touch of any other object, without being liable to all the effects conſequent on contuſions, and that too with little proſpect of relief, the ſpring of the Fibres being the principal inſtrument Nature applies in the recovery of ſuch caſes. But beſides all theſe inconveniences, the animal in all ſuch caſes as required a large and ſpeedy depletion of the veſſels, by which a ſudden relaxation is immediately produced, muſt either have ſunk under it, or at beſt never have recovered its former vigour and activity, which even as the caſe now ſtands, where great evacuations have been prepoſterouſly made, is often very difficult to reſtore.

And hence it ſeems to be, that the weakeſt veſſels I have hitherto examined, are capable of ſuſtaining the weight of an Atmoſphere without burſting, as appears by the trial of the Splenic and Emulgent Veins in Exp. XXXV, XXXVII, XXXIX, XLVI, which tho' prevented from breaking by the largeneſs of their pores, and laxity of their Fibres, would undoubtedly have ſuſtained a ſomewhat greater weight, than is there expreſſed before a rupture had ſucceeded, had the air been ſufficiently retained. To which inſtances, for the greater confirmation, I ſhall ſubjoin the following.

§ 12. I fixed part of the Pia Mater of a dog (the thinneſt ſeparable membrane of an animal body) to the Condenſer, and the preſſure upon it was equal to 1.36 Atmoſphere at the inſtant that it burſt. Now the area of this membrane was 0.03143 parts of a ſquare inch; hence it appears that the weight required to break it was 9 ounces, 3 pennyweights, 1 $\frac{1}{2}$ grains. The thickneſs of this membrane, being carefully taken, was no more than $\frac{1}{1698}$ of an inch.

§ 13. Part of the Pericardium of the ſame dog, bore upon being compreſſed with air the preſſure of 6.18 Atmoſpheres without burſting; but a ſmall ſtream of air at this time finding a paſſage thro' it, prevented the increaſe of ſo great a condenſation, as was neceſſary to burſt it. If therefore we eſtimate the preſſure ſuſtained by this membrane upon the foregoing area, we ſhall find the weight it bore equal to 3 pounds, 5 ounces, 12 pennyweights. The thickneſs of this membrane was $\frac{1}{413}$ of an inch, and conſequently the Pericardium exceeded the thickneſs of the Pia Mater in the proportion of 33 to 8 nearly, and in ſtrength in the proportion of 45 to 10 nearly.

§ 14. Common Experience ſufficiently informs us, how much weak, lax, and delicate conſtitutions ſuffer upon great and ſudden alterations in the weight of the Atmoſphere; how great then the diſorders muſt have been, had they not been framed with this extraordinary degree of ſtrength, I have no occaſion to explain, and the more eſpecially, if we conſider, how frequently hæmorrhages and other ruptures of the veſſels are occaſioned by this very cauſe, where their ſtrength is diminiſhed by any preternatural diſtention,

tention, acrimony of the humors, or the like.

§ 15. Hence alſo we have a very obvious ſolution, why Fevers frequently occaſion great changes, as well to the advantage as detriment of the conſtitution, excluſive of thoſe more obvious ones relating to the forming or removing obſtructions; ſince it is manifeſt from the very ſymptoms attending ſuch diſorders, that whatever the natural proportion between the ſolids and fluids might have been before the attack of the diſtemper, that ratio muſt frequently be deſtroyed, and a new one produced, ſometimes to the advantage, but often to the damage of the conſtitution.

§ 16. Hence alſo it appears, why Intermittents and ſuch other ſpring Fevers, as only moderately puſh open and diſtend the veſſels without damaging the Viſcera, or ſtraining the Conſtitution, are obſerved rather to invigorate than weaken thoſe they attack; as alſo why in young perſons, they ſhould be ſucceeded by a remarkable increaſe of their growth and ſtature.

EXPERIMENT XXXIII.

§ 1. The diameter of the Aorta deſcendens in a ram, exactly at the diviſion of the great trunk, which proceeded immediately from the left ventricle of the heart, was 0.55 of an inch, and the Aorta aſcendens was 0.41 of an inch in diameter. The thickneſs of the firſt was 0.102 of an inch, and that of the latter was 0.073. The diameter of the Vena cava aſcendens, correſponding to the Aorta deſcendens was 0.72 of an inch, and the Vena cava deſcendens was 0.56 of an inch in diameter.

§ 2. The diameter of the Aorta deſcendens in an ewe, taken in the ſame manner as the like veſſel in a ram in the preceeding ſection, was 0.46 of an inch, the diameter of the Aorta aſcendens was 0.33 of an inch. The thickneſs of the firſt of theſe Arteries in the ewe was 0.078 of an inch, and that of the latter was 0.0571 of the ſame. The Vena cava aſcendens was in diameter equal to 0.59 of an inch, and the Vein correſponding to the Aorta aſcendens was in diameter equal to 0.435 of an inch.

§ 3. Hence it appears, that the capacity of the Vena cava aſcendens in the ram, was ſuperior to that of an equal length of the correſponding Artery, in the proportion of 5184 to 3025, that is, as 1713 to 1000 nearly. And the capacity of the Vena cava deſcendens, was ſuperior to that of an equal length of the Aorta aſcendens in the ſame animal, in the proportion of 3136 to 1681, that is, as 1865 to 1000 nearly.

§ 4. In like manner it appears, that the capacity of the Vena cava aſcendens in the ewe, was ſuperior to that of an equal length of the Aorta deſcendens, in the proportion of 3481 to 2116, that is, as 1645 to 1000 nearly; and the capacity of the Vena cava deſcendens in the ſame was to that of an equal length of the correſponding Artery, *viz.* the Aorta aſcendens, in the proportion of 189225 to 108900, that is, in the proportion of 1737 to 1000 nearly.

§ 5. Hence it is evident, that the capacity of the Vena cava aſcendens and deſcendens in the ram, with reſpect to the capacity of an equal length of their correſponding Arteries, is ſuperior to the capacity of the correſponding Veins in an ewe, with relation to the capacity of an equal length of their reſpective Arteries in the proportion of 10969344, 342410400, to 10530025, 318087225 reſpectively, that is, as 1041, and 1076 to 1000 nearly.

§ 6. Comparing the diameters which belong the deſcending and aſcending Arteries in a ram and an ewe, it is evident, that the capacity of the Aorta deſcendens in a ram, with reſpect to the capacity of an equal length of the Aorta aſcendens in the ſame, is to the capacity of the Aorta deſcendens, with reſpect to the capacity of an equal length of the Aorta aſcendens in an ewe, in the proportion compounded of the direct ratio of the capacities of equal lengths of the deſcending Aortas in the ram and the ewe, and the reciprocal ratio of the capacities of equal lengths of the aſcending Aortas in the ſame, that is, as it appears from computation, in the proportion of 3294225 to 3556996; and conſequently the capacity of the deſcending Artery in the ewe, with reſpect to the capacity of an equal length of the aſcending Aorta, was ſuperior to the capacity of the deſcending Artery in a ram, with relation to the capacity of an equal length of the Aorta aſcendens in this animal, in the proportion of 1082 to 1000 nearly.

§ 7. In comparing the capacities of the Veins and correſponding Arteries of the ram and the ewe mentioned in Exp. XXI, XXIII, XXVIII, XXXI, it is evident, that the capacity of the Vein above the Emulgents and of the Iliac Vein, with reſpect to the capacity of an equal length of their reſpective Artery in a ram, is ſuperior to the capacity of the Veins performing the ſame office in an ewe, with reſpect to the capacity of an equal length of their reſpective Artery, in the proportion of 3080025, 22562500 to 2822400, 20115225 reſpectively; that is, the capacities of theſe Veins in the ram, are ſuperior to the capacities of thoſe in an ewe, with relation to the capacities of the Arteries they correſpond to, in equal lengths to the Veins in both animals, in the proportion of 1091, 1121 to 1000 nearly.

§ 8. Comparing the thickneſſes of the preceeding Arteries in the ram and the ewe with their reſpective diameters, as they are given in this Experiment, and afterwards the proportions which the coats of theſe Arteries bear to the fluid contained in their reſpective cavities together, it is evident, that the coat of the deſcending Aorta in the ram, with reſpect to the blood contained in its cavity, is ſuperior in bulk to the coat of the correſponding Artery in an ewe, with reſpect to the fluid contained in an equal length of theſe veſſels, in the proportion of 562889856 to 507764400, that is nearly in the proportion of 1108 to 1000. Thus alſo it will be found, that the bulk of the coat of the aſcending Aorta in the ram, with reſpect to the fluid it acts upon, is ſuperior to that of the coat of the aſcending Aorta in the ewe, with relation to the fluid contained in an equal length of this veſſel to that in the ram, in the proportion of 1535820400 to 14862332884, that is nearly in the proportion of 1033 to 1000.

§ 9. Comparing § 1. of this Expement with § 7. Exp. XXVIII, it is evident,

dent, that the capacity of the Vein of the ram above the Emulgents in that Experiment, with reſpect to the capacity of an equal length of the correſponding Artery, is to the capacity of the Vena cava aſcendens, with reſpect to the capacity of an equal length of the correſponding Aorta deſcendens in this Experiment, in the proportion of 12780625 to 4665600; and conſequently the capacity of the Vena cava at the Emulgents, was ſuperior to that of the Vena cava diſcharging its contents into the Sinus Venoſus, when compared together with relation to the capacities of the Arteries they correſpond to, in the manner above-mentioned, in the proportion of nearly 2739 to 1000. Now the thickneſs of the Vena cava aſcendens in this Experiment was 0.0052 of an inch. Hence it is evident, that the bulk of the coat of the preceeding Vein above the Emulgents, with reſpect to the fluid contained in its cavity, is to the bulk of the coat of the Vena cava aſcendens near the right auricle of the heart, with reſpect to the fluid contained in its cavity equally long with that of the former, in the proportion of 4822364 16 to 63730576; and conſequently, tho' the blood acted upon by the Vena cava aſcendens near the right auricle of the heart, was ſuperior in quantity to that contained in an equal length of the Vein above the Emulgents, in the proportion of 1227 to 1000 nearly; yet the coat of the Vein at the origin of the Emulgent veſſels, was ſuperior in bulk to that of the Vena cava aſcendens, with relation to the blood acted upon by an equal length of each Vein, in the proportion of nearly 7566 to 1000.

§ 10. That the circulation is in general more ſlow and languid in females than males, is frequently obſerved by practical writers, but the cauſe little farther inquired, than by ſuppoſing the whole animal fabrick more weak, lax, and delicate; but from § 2, 8. Exp. XXXII, § 5, 6. Exp. XXX, § 8, 9. Exp. XXXIII, as well as from the leſs ſtrength and denſity of the arterial veſſels of females (*a*), we are furniſhed with a more ſubſtantial reaſon, why the circulation of the blood is naturally ſlower, and the pulſe weaker in theſe than males. For the capacities of the Arteries being ſhewn in the preceeding ſections to be greater, an equal portion of blood diſcharged by the heart would neceſſarily produce a leſs impulſe on the coats of the veſſels,

---

(*a*) Exp. XVIII, XIX.

and conſequently theſe, a leſs renixus on the contained fluid, even tho' we ſhould ſuppoſe the ſtrength of the Fibres equal in both caſes, which is far from being fact, the contrary appearing by ſeveral of the foregoing Experiments; whence of neceſſity the blood muſt both remain longer in the Arteries, and a weaker and ſlower circulation enſue; the quantity to be impelled being greater in proportion to the moving force.

§ 11. This appears alſo from the capacities of the Veins, which are diminiſhed in proportion to the inlargement of the Arteries (*a*); there being no occaſion for veſſels of a large capacity in order to return a leſs quantity of blood, for ſo it may be eſteemed on account of the ſlowneſs of its motion, leſs being derived into them

---

(*a*) § 5, 7. Exp. XXXIII.

in a given time than in males. Nay had it been otherwiſe, the animal muſt have laboured under innumerable maladies. For the blood wanting here thoſe vibrations, which kept it fluid whilſt in the Arteries, muſt, had the Veins been as large as in the males, have moved extremely ſlow, and condenſed into grumes, before it had arrived at the heart; the conſequence of which would have been obſtructions in the lungs, aſthmas, conſumptions, *&c.* So exactly nice is every part adjuſted to its deſtined uſe, that it is altogether impoſſible for the moſt inlarged underſtanding either to comprehend the whole, or even ſee how the leaſt parts could have been otherwiſe framed, ſo as to have anſwered the deſigned purpoſes in any tolerable manner. It were needleſs to apply this reaſoning to ſhew how the direct contrary muſt happen to males, as the effect muſt always be determined by its cauſe, and conſequently where that ſtructure is different, or contrary, the effect muſt be ſo too.

§ 12. But this greater capacity of the Arteries in proportion to that of the Veins of females, is not the only difference in this reſpect with regard to the female ſex. For the coats of the Arteries in males tho' loaded with a ſmaller proportion of blood (*a*), are much ſtronger, thicker, and denſer than thoſe in females (*b*); whence not only a briſker circulation muſt enſue, but each part of the body being framed of veſſels more ſtrong, ſpringy and elaſtic, the whole muſt be more robuſt, and capable of bearing more laſting and greater fatigues.

(*a*) § 8. Exp. XXX. § 12. Exp. XXXIII.
(*b*) § 5, 8. Exp. XXXII. § 8. XXXIII.

§ 13. There remains ſtill another difference in the proportion of the ſanguineous veſſels of males to thoſe of females, beſides thoſe above-mentioned, *viz.* the different proportion which the ſuperior veſſels bear to the inferior, which holds true in brutes as well as human bodies (*a*); but this being obſerved and explained by the very learned Phyſicians Dr. *Freind* and *Pitcairn*, I ſhall not trouble the reader with it.

§ 14. Beſides the different proportions of the veſſels with reſpect to the ſex, male and female, there are two general circumſtances relating to the Vena cava aſcendens common to all or moſt animals, which are very little, if at all, taken notice of by Anatomiſts, *viz.* the larger capacity of this Vein in the Abdomen, in proportion

---

(*a*) § 6. Exp. XXXIII.

to the blood it receives from the correſponding Aorta ; being very little inferior in capacity to that of the ſame Vein in the Thorax (*a*), of which I have ſpoken already at § 8, 9. Exp. XXVIII. and 2dly, the ſuperior thickneſs of its coat during its ſtay in the lower belly, occaſioned by an additional coat it receives from the Peritonæum, by which means its cavity is preſerved more free and open, and it approaches in ſome degree to an arterial nature, at leaſt much more ſo than elſewhere (*b*). In conſequence of this admirable contrivance, it becomes capable not only of receiving a large quantity of the returning blood with the greater facility, and there containing it as in a Reſervoir to ſupply the equable diſcharges from the heart, but

(*a*) § 9. Exp. XXXIII.
(*b*) § 9. Exp. XXXIII.

alſo its coats being hereby rendered more elaſtic, do by the alternate action of the abdominal muſcles propel it forward with the greater facility. Whereas had its texture been equally thin, and no more capable of reſiſting an external preſſure than its ſuperior part in the Thorax, or the Cava deſcendens, its cavity would have been much more diminiſhed by the ſuperincumbent preſſure, and its coats thro' the want of a ſufficient degree of reſiſtance muſt either have collapſed, or ſo nearly approached each other by the conſtant weight and preſſure of the inteſtines, bladder, and other viſcera, as inſtead of promoting, very much to have retarded, if not intirely prevented, the due and equable return of the blood from the lower parts.

EXPERIMENT XXXIV.

§ 1. The ſplenic Artery of the man, part of whoſe Aorta we found the ſtrength of in EXP. XIV, being fixed to the Condenſer, I compreſſed the air in the ſealed top of the Gage, with a force equal to that of 6.2 Atmoſpheres, before I was able to break the coats of this ſmall Artery.

§ 2. The diameter of this Artery was 0.12 of an inch, therefore an inch in length of its ſurface will be expreſſed by the Logarithm 9.5764565; and the weight incumbent on it from the preſſure of 6.2 Atmoſpheres, will be equivalent to ſo many ounces troy, as correſpond to the tabular Logarithm 2.6995379, that is, to 41 pounds, 8 ounces, 13 pennyweights.

§ 3. Comparing the area of this ſplenic Artery with that of the great deſcending Aorta of the ſame perſon mentioned at § 2. Exp. XIV, it will be found, that the ſplenic Artery upon an equal area with that of the great trunk would not have burſt without the weight of 173 pounds, 10 ounces, 6 pennyweights.

§ 4. Hence it is manifeſt, that the texture and cohæſion of the Fibres, which compoſe the ſplenic Artery, is ſuch, as even to render it ſtronger than a portion of equal area of the great Aorta deſcendens where its diameter was ½ inch, in the proportion of 1319 to 1000 nearly.

Experiment XXXV.

§ 1. The ſplenic Vein correſponding to the Artery in the preceeding Experiment, permitted the air ſo freely to eſcape thro' its pores, after the preſſure given it from the condenſation, amounted to ſomething more than the weight of one Atmoſphere, that the greateſt force with which I could compreſs the air in the top of the Gage was, I found, equal to 1.43 Atmoſpheres.

§ 2. The diameter of this Vein was 0.43 of an inch; hence by comparing the area of this Vein an inch in length with the area of an inch ſquare, and the weight of a column of Quickſilver incumbent on that, when the altitude is equal to 1.43 Atmoſpheres, it appears, that the weight ſuſtained by an inch length of this Vein will amount to 34 pounds, 5 ounces, 14 pennyweights.

§ 3. The ſurface of this Vein an inch in length, and the foregoing weight incumbent on it, being expreſſed in Logarithms, are 0.1306553, 2.6166810 reſpectively; hence comparing theſe with the Logarithms, which expreſs the area, and weight incumbent on it, with relation to the ſplenic Artery, as they are given in the preceeding experiment, it appears, that the ſplenic Artery upon an area equal to that of its correſponding Vein, would not have yielded to any weight leſs than that of 149 pounds, 5 ounces, 12 pennyweights.

§ 4. Hence it appears, that a portion of the ſplenic Artery of equal area with that of its correſponding Vein was ſuperior in ſtrength to it, in the proportion of 4336 to 1000 nearly.

EXPERIMENT XXXVI.

§ 1. The ſplenic Artery of the ewe mentioned in EXP. XXII, gave no admittance to the air, till the preſſure amounted to that of 4.62 Atmoſpheres, at which inſtant its Fibres burſt aſunder.

§ 2. The diameter of this Artery being 0.08 of an inch, its area an inch in length will correſpond to the Logarithm $\bar{9}.4003653$, and the weight incumbent on this area from the preceeding preſſure, will be found equivalent to the Logarithm 2.3956970, that is, to 20 pounds, 8 ounces, 14 pennyweights, 4 grains.

§ 3. The area of an inch in length of the Aorta of this ewe was equivalent to the Logarithm $\bar{9}.9294189$, and the weight required to break it was equal, when expreſſed in Logarithms, to 2.8066513. Hence it is evident from the compariſon of theſe with the Logarithms anſwering thereto in the preceeding ſection, that the weight required to break the ſplenic Artery, ſuppoſing its area equal to that of the Aorta, muſt have been 70 pounds, 0 ounce, 18 pennyweights, 9 grains.

§ 4. Hence it appears, that a portion of the ſplenic Artery of equal area with the Aorta at the origin of the Emulgent veſſels, was ſuperior in ſtrength to it in this ewe, in the proportion of 1312 to 1000 nearly.

§ 5. Comparing after the ſame manner the ſtrength of equal portions of the Splenic and Iliac Artery of the ſame ewe, as we find it given in Exp. XXX. it appears, that the Splenic Artery was ſuperior in this reſpect to the Iliac Artery, when compared in equal areas together, in the proportion of 148 to 100 nearly.

EXPERIMENT XXXVII.

§ 1. The Splenic Vein being fixed to the Condenſer, no rupture could be made from the ready eſcape, which the air made through its pores, inſomuch, that the preſſure could never be increaſed beyond that of 0.96 Atmoſpheres.

§ 2. The weight incumbent on an inch length of this Vein, whoſe diameter was 0.28 of an inch, from the preceeding preſſure, will be found by computation to be equal to 15 pounds, 0 ounce, 18 pennyweights; and conſequently the Splenic Artery exceeded the ſtrength of an equal portion of this Vein with reſpect to ſurface, in the proportion of 4812 to 1000 nearly.

§ 3. Comparing the preceeding ſection with § 2. Exp. XXXI, it is evident, that had the Iliac Vein in the ſame ewe been equal in area to this here of the Splenic, the force required to break it, muſt have been equivalent to the weight of 52 pounds, 9 ounces, 3 pennyweights, 4 grains.

§ 4. Hence it is manifeſt, that the Iliac Vein was ſuperior in ſtrength to an equal area of the Splenic in the ſame animal, in the proportion of nearly 35 to 10.

EXPERIMENT XXXVIII.

§ 1. The Emulgent Artery of the ram mentioned in EXP. XX. being fixed to the Condenſer, it ſuſtained the preſſure of 5.56 Atmoſpheres, without any previous leakage of air, till by this means a perfect rupture of its coats was made.

§ 2. The diameter of this branch of the Artery was 0.1 of an inch, and conſequently its area an inch in length will be expreſſed in parts of a ſquare inch by the Logarithm $\bar{9}.4973444$, and the weight of the column of Mercury, taken in ounce troy, by the value of the Logarithm 2.5731539, equal as appears by computation to 31 pounds, 2 ounces, 4 pennyweights, 19 grains.

§ 3. The Logarithm 2.9446879 expreſſes the weight incumbent on an inch in length of the trunk of this Emulgent Artery, and the Logarithm 5.9745117 expreſſes the area (*a*). Hence comparing theſe Logarithms with the correſponding ones in the preceeding ſection, it appears, that had the area of the Emulgent Artery been equal to that of the trunk it was derived from, it would not have burſt till the preſſure had been equal to the weight of 93 pounds, 7 ounces.

§ 4. Hence it is manifeſt, that a portion of the Emulgent Artery, was ſtronger than a like one with reſpect to

---

(*a*) § 2. Exp. XX.

to the ſurface of the trunk itſelf in this ram, in the proportion of 51 to 40.

§ 5. The weight incumbent on an inch in length of the Iliac Artery of the ſame ram was 44 pounds, 2 ounces, 6 pennyweights, 9 grains; comparing therefore this area and weight with thoſe belonging the Emulgent Artery in § 2. it appears, that the Emulgent Artery would have required the additional weight of 29 pounds, 7 ounces, 13 pennyweights, 14 grains to break it, had its area been equal to that of the Iliac Artery.

§ 6. Hence it is manifeſt, that the Emulgent Artery ſurpaſſed the ſtrength of the Iliac in the ſame animal, when compared in equal areas together, in the proportion of 1376 to 1000 nearly.

EXPERIMENT XXXIX.

§ 1. The Emulgent Vein correſponding to the Artery in the preceeding Experiment, tho' it did not burſt with the preſſure of 1.36 Atmoſpheres, yet during the compreſſion, air ſo plentifully eſcaped thro' its coats, that it could never be condenſed with any greater force than that above-mentioned.

§ 2. This Vein was in diameter 0.34 of an inch; hence it appears, by computing the preſſure of 1.36 Atmoſpheres upon an area of it an inch in length, that the weight incumbent on it was equal to 25 pounds, 11 ounces, 0 pennyweight, 10 grains.

§ 3. The Logarithm of this weight is 2.4927998; hence comparing this weight and area with thoſe belonging the correſponding Artery, it appears that the Emulgent Artery, had its area been equal to that of the Vein correſponding to it, would have required the weight of 105 pounds, 11 ounces, 14 pennyweights to break it.

§ 4. Hence it is manifeſt, that the Emulgent Artery was ſuperior with reſpect to ſtrength, to the Emulgent Vein when compared in equal areas together, in the proportion of 4088 to 1000 nearly.

§ 5. Comparing this Experiment with Exp. XX, XXI, XXV, XXVIII, in which we found the ſtrengths of the Aorta at the Emulgents and of the Iliac Artery in the ſame animal, and likewiſe the ſtrengths of the Veins correſponding thereto, it is evident, that the Vena cava and Iliac Vein, with relation to their correſponding Arteries, are ſuperior with reſpect to ſtrength, to the Emulgent Vein in the ſame ram, with reference to the ſtrength of its correſponding Artery, in equal areas to the former veſſels, in a proportion compounded of the direct ratio of the preſſures incumbent on the areas of the Veins at the moment of their burſting, and of the reciprocal ratio of the forces required to break the correſponding Arteries in equal portions to the Veins; that is as appears by computation, in the proportion of 269104, 232408 to 59296, 54944 reſpectively; and conſequently the ſtrength of the Vena cava at the Emulgents, and of the Iliac Vein with reſpect to that of an equal area of their correſponding Arteries, is ſuperior to the ſtrength of a like portion of the Emulgent Vein, with relation to its correſponding Artery, in the proportion of nearly 4538 to 1000 and 423 to 100 reſpectively.

§ 6. In comparing the areas of the Veins and Arteries in the preceeding Experiments together in equal lengths, it is manifeſt, that the Splenic Vein is ſuperior in capacity to that of an equal length of the Splenic Artery in the man, in the proportion of 1284 to 100 nearly, and that in the ewe, the capacity of the Splenic Vein with reſpect to that of an equal length of the correſponding Artery, is ſuperior to the capacity of the Iliac Vein in the ſame animal, with reſpect to that of an equal length of its correſponding Artery, in the proportion of 283024 to 33856, that is, as 836 to 100 nearly.

§ 7. Thus alſo it appears, that the capacity of the Emulgent Vein is ſuperior to that of an equal length of the correſponding Artery in the proportion of 1156 to 100; and conſequently the capacity of this Vein with reſpect to that of an equal length of the Emulgent Artery, is ſuperior to the capacity of the Vena cava at the Emulgents, or of the Iliac Vein, with relation to the capacities of an equal length of their reſpective Arteries, in the proportion of 10404, 439569, to 4225, 62500 reſpectively, that is in the firſt inſtance as 2462 to 1000, and in the ſecond with relation to the Iliac Vein, as 703 to 100 nearly.

EXPERIMENT XL.

§ 1. The Emulgent Artery was in thickneſs equal to 0.037 of an inch, and the Splenic Artery was 0.028 of an inch thick in EXP. XXXVI. The Emulgent Vein correſponding to the preceeding Artery was 0,0036 of an inch thick, and the Splenic Vein was in thickneſs equal to 0.0025 of an inch.

§ 2.

§ 2. Comparing the thickneſſes of theſe veſſels with their reſpective diameters, as given above in § 2. Exp. XXXVIII, XXXIX, XXXVI and XXXVII, it is evident, that the fluid contained in the cavity of the Emulgent Artery, is to the coat that contains it, in the proportion of 1000 to 2027 nearly, and conſequently the bulk of the ſolids in the Emulgent Artery, with reſpect to the fluid they act on, is ſuperior to the bulk of the ſolids acting on the fluid contained in an equal length of the trunk it was derived from, and to thoſe of the Iliac Artery in the ſame animal, with reſpect to the fluid they act on in equal lengths to the former, in the proportion of 182484, 7709949 to 73216, 2239264 reſpectively, that is, as 2629 to 1000, and as 344 to 100 nearly.

§ 3. Thus alſo it appears, that the fluid in the cavity of the Splenic Artery, is, to the coat that contains it, in the proportion of 6400 to 12096; and conſequently the bulk of the Splenic arterial Coat in the ewe, with reſpect to the fluid it acts upon, is ſuperior to the bulk of the coat of the Iliac Artery in the ſame animal, with reſpect to the fluid contained in an equal length of this veſſel, in the proportion of 4366656 to 1254144, that is nearly as 348 to 100.

§ 4. On the contrary it appears from computation, that the bulk of the ſolids in the Vena cava at the Emulgents and thoſe of the Iliac Vein in the ram, with reſpect to the fluids they act on, is ſuperior to the bulk of the ſolids acting on the fluid contained in an equal length of the Emulgent Vein, in the proportion of 107535744,

17090304,

17090304, to 20904624, 3092400 reſpectively, that is, nearly as 514, 552 to 100. In like manner it appears that the bulk of the ſolids in the Iliac Vein with reſpect to the fluid they act upon, is ſuperior to the bulk of the ſolids acting on the fluid contained in an equal length of the Splenic Vein in the ſame animal, the ewe, in the proportion of 8313536 to 1494425, that is, as 556 to 100 nearly.

§ 5. Hence we may obſerve, upon how narrow a bottom the ingenious Dr. *Keil* has founded his eſtimation of the quantity of blood in an animal body. For tho' by comparing the area of the Aorta and Vena cava in a calf with the thickneſs of theſe veſſels, he obtained the proportion of the fluid to the ſolid in each, yet theſe data were extremely inſufficient for determining that difficult Queſtion, with regard only to the quantity circulating in the larger branches of the arterial ſyſtem; inaſmuch as the rule and proportion laid down by him as a baſis to proceed on in that Inquiry, is, by ſeveral of the foregoing ſections, not only varied in every branch (*a*), but directly contradicted in ſome of the next branches iſſuing from it (*b*). The few inſtances we have here enumerated, are however ſufficient to ſhew us, what care and circumſpection we ought to employ in all our inquiries, into that complicated machine, an animal body. For however uniform the workmanſhip of nature may appear in the formation of the correſponding organs in different animals, yet the texture of the ſeveral veſſels which compoſe the ſame individual,

---

(*a*) § 2, 3. Exp. XXVI, § 9. Exp. XXXIII.

(*b*) § 6, 7. Exp. XXXIX, § 2, 3, 4 Exp. XL.

is, we ſee, infinitely various, and conſequently where the particulars for our obſervation are ſo numerous, we ſhall be in perpetual danger either of advancing opinions abſolutely uncertain for certain truths, or things abſolutely falſe for matters of fact and reality, unleſs we will be at the labour and expence of examining the ſtructure ſhe has framed, as it were, inch by inch; and learn by a particular Encheireſis, what is the diſpoſition, what the order, what the relation of the ſeveral component parts, by which its movements are beſt acquired, and its being preſerved to that period of time for which it was naturally intended.

§ 6. Hence alſo it appears, on how weak a baſis every general Hypotheſis relating to the ſecretions in an animal body muſt be founded; ſince 'tis demonſtrable, that not only the different angles at which the branches ariſe from their trunks, as well in the larger as in their minuter ramifications, are extremely various, but even the Arteries themſelves are almoſt infinitely diverſified in their ſtrength and capacity with regard to the moving fluid. The conſequence of this muſt be, that in ſome parts their action will be more ſtrong and briſk, in others more weak and ſluggiſh, and that in ſuch peculiar proportion, as is neceſſary to prepare and ſecrete each particular fluid; which can never be explained with any tolerable degree of exactneſs and certainty, till theſe are better determined, and their different proportions to each other adjuſted.

EXPERIMENT XLI.

§ 1. The Vena porta of the ewe ſheep mentioned in ſeveral of the foregoing Experiments did not ſuffer any air to eſcape through, till the preſſure given from the continuance of the condenſation was equal to 4.98 Atmoſpheres, at which time a ſmall ſtream of air paſſing thro' its coats, prevented a perfect rupture.

§ 2. The diameter of this Vein was 0.49 of an inch, its area an inch in length, will correſpond to the Logarithm 0.1875207, and the weight it bore upon this area, will, if taken in ounce troy, correſpond to the Logarithm 3.2154397, and ſhews that the preſſure amounted to 136 pounds, 10 ounces, 4 pennyweights, 14 grains.

§ 3. The Logarithms 0.2455127, 3.1942505 reſpectively denote the area of an inch in length of the Vena cava of the ſame ewe, and the weight required to break it (*a*). Hence com-

---

(*a*) § 2, 3. Exp. XXIII.

paring theſe with the foregoing Logarithms in § 2, it is manifeſt, that had the area of the Vena porta been equal to this of the Vena cava, the weight to break it muſt have been 156 pounds, 4 ounces, 17 pennyweights, 19 grains.

§ 4. Hence it is evident, that the Vena porta was ſuperior in ſtrength to a portion of the Vena cava of equal area with it in the ſame ewe in the proportion of 6 to 5.

§ 5. Comparing the area and weight ſuſtained on it by the Vena porta in this Experiment, with thoſe correſponding to the Aorta of the ſame animal in Exp. XXII. it is evident, that had the area of the Aorta been equal to this here of the Vena porta, yet it would only have ſuſtained the weight of 96 pounds, 8 ounces, 16 pennyweights.

§ 6.

§ 6. Hence it is manifeſt, that the Vena porta was ſuperior in ſtrength to the great deſcending trunk of the Aorta at the Emulgents, when taken in equal areas, in the proportion of 1414 to 1000 nearly.

§ 7. The area of an inch in length of the Splenic Vein being compared with the area of the Vena porta, and likewiſe the weights required to break theſe areas reſpectively, as they are given in this and Exp. XXXVII, it is evident, that had the area of the Splenic Vein been equal to that of the Vena porta in the ſame ewe, yet the weight incumbent on it, and to which it would have yielded, would have been no more than that of 26 pounds, 4 ounces, 11 pennyweights, 4 grains.

§ 8. Hence we learn, that the Vena porta was ſtronger than a portion of the Splenic Vein of equal area with it in the proportion of 5187 to 1000 nearly.

§ 9. It appears from § 2. Exp. XXIII, that the Aorta of the ewe ſheep required the weight of 53 pounds, 4 ounces, 14 pennyweights, to break an inch in length of its ſubſtance. Now from Exp. XXXII, and XL, it is farther evident, that the thickneſs of this Aorta and of the Splenic Artery was 0,044, 0,028 of an inch reſpectively, and the Vena porta in this was 0,0053 of an inch thick. If now we conceive the Aorta remaining in its texture and ſurface ſtill the ſame, but its thickneſs varied ſo as to be diminiſhed to that of the Splenic Artery or Vena porta in the ſame animal, it is evident, that by reducing the preceding thickneſſes of theſe veſſels to their value in Logarithms, and comparing them with the Logarithms of the weights above-mentioned, that the Aorta would, in the firſt of theſe ſuppoſitions, have required to break the ſame area, no more than the weight of 33 pounds, 11 ounces, 14 pennyweights, 4 grains; and in the ſecond inſtance, no more than the weight of 6 pounds, 5 ounces, 3 pennyweights, 10 grains. Whereas it appears from § 3. Exp. XXXVI, and from § 5. of this Experiment, that the Splenic Artery and Vena porta were of ſo different a texture from the Aorta in the ſame animal, that a portion of theſe veſſels, tho' of no greater area or thickneſs than that juſt above aſſigned to this great deſcending trunk, would not have broke unleſs the weight upon them had been equal to 70 pounds, 0 ounce, 18 pennyweights, 9 grains, 75 pounds, 6 ounces, 8 pennyweights, 19 grains reſpectively.

§ 10. Hence we may ſee, how many concluſions in the animal œconomy, as well as many arguments of the Anatomiſts would have been much better grounded, had they ſtudied invention leſs, and nature more. For they finding the Arteries in general upon every ſubdiviſion to decreaſe in the thickneſs of their coats, have erroneouſly concluded their ſtrength to decreaſe in the ſame proportion; which is ſo far from being true, that whoever will examine the ſtrength of the thinneſt veſſels, will find that theſe are endowed with a much greater degree of ſtrength in proportion to their thickneſs than the other. Nay and not only ſo, but that ſeveral veſſels whoſe coats are extremely thin, exceed the ſtrength of the Aorta itſelf, whoſe coats are more than ten times as thick.

EXPERIMENT XLII.

§ 1. The Aorta of an old dog a terrier being cut off at the origin of the Emulgent Arteries, and fixed to the Condenſer, the air was compreſſed with a force equal to that of 4.07 Atmoſpheres before a rupture or leakage could be made in its coats.

§ 2. The diameter of this part of the Artery was 0.11 of an inch, and conſequently its area an inch in length will be expreſſed in parts of a ſquare inch by the Logarithm $\bar{9}.5386994$. Now the weight of one Atmoſphere upon an inch ſquare being equal to 214.136 ounces troy, it is manifeſt, that the weight of 4.07 Atmoſpheres upon this area will be equivalent to 25 pounds, 1 ounce, 5 pennyweights, 19 grains.

EXPERIMENT XLIII.

§ 1. The Vena cava correſponding to the Aorta in the preceeding Experiment, and tried in the ſame manner as that, did not ſuffer any air to eſcape, till the preſſure was equal to 3.71 Atmoſpheres, with which it burſt.

§ 2. The diameter of this Vein at the Emulgents was 0.23 of an inch; and conſequently the Logarithm 9.8591383, correſponding to 0.723 parts of a ſquare inch, will give the area of an inch in length of this Vein. Hence it is evident, that the Logarithm 2.7592019 will correſpond to ſo many ounces troy, as preſſed upon this area of the Vein at the time of its burſting, which by computation amounts to the weight of 47 pounds, 10 ounces, 7 pennyweights, 19 grains.

§ 3.

§ 3. Comparing the weight neceſſary to break the preceeding area of this Vein with thoſe belonging the correſponding Artery, as they are given in the preceeding Experiment, it appears, that had the Aorta of this dog been equal in area to its correſponding Vein at the Emulgents, it would not have burſt unleſs the weight had been equivalent to 52 pounds, 6 ounces, 2 pennyweights, 9 grains.

§ 4. Hence it appears, that the Aorta of this old terrier was ſuperior in ſtrength to the correſponding Vein at the origin of the Emulgent Veſſels, when compared in equal areas together, in the proportion of 1097 to 1000 nearly. And conſequently, as we have already ſhewn, that age continually adds to the denſity of the Artery in ſeveral of the foregoing Experiments;

ments (*a*); ſo from hence it is no leſs manifeſt, that they are conſtantly acquiring more ſtrength, inſomuch that thoſe Veins, which in young animals were in equal areas ſtronger than their correſponding Arteries, loſe their ſuperiority over them in this reſpect in old ones.

§ 5. 'Tis a common obſervation, and verified by innumerable inſtances, that ſuch as early in youth habituate themſelves to exceſſive drinking, and other debaucheries of that kind, have their conſtitutions broken and ſhattered in much ſhorter time, than thoſe who later in life enter upon the like pernicious courſes; which from the increaſing ſtrength of the arterial veſſels is eaſily explained. For as the body is by ſuch a method of living

---

(*a*) See Exp. VI. to Exp. XII.

kept conſtantly in a febrile ſtate, it cannot otherwiſe happen, but that the arterial veſſels of young perſons, on which the rarefying humors exert their principal force, muſt ſuffer greater alterations in their tone and dimenſions, than of thoſe that are older, whoſe ſuperior ſtrength renders them more capable of reſiſting the preternatural impetus of the circulating humors. Not to mention the effect of youth itſelf excluſive of theſe debaucheries, in which the natural force of the fluids themſelves is in ſome degree an overbalance to the ſolid parts, as appears by the increaſing ſtature of all animals, as is before ſufficiently explained.

EXPERIMENT XLIV.

§ 1. The Vena porta of the ſame dog endured without any viſible leakage of air the preſſure of 5.73 Atmoſpheres,

ſpheres, before a rupture ſucceeded from the continuance of the condenſation.

§ 2. The diameter of this Vein was 0,2 of an inch, and therefore its area an inch in length will correſpond to the Logarithm 9.7983053, and the weight incumbent on it will be found equal to the value of the Logarithm 2.8871496 taken in ounces troy; that is, as appears by computation, to 64 pounds, 3 ounces, 2 pennyweights, 9 grains.

§ 3. Comparing the area of an inch in length, and the weight ſuſtained upon it by the Aorta of this dog in Exp. XLII, with thoſe given in the preceeding ſection for the Vena porta in the ſame animal, it is evident, that had the area of the Aorta been equal to that of the Vena porta, yet the weight required to break it, would not have been more than that of 45 pounds, 7 ounces, 15 pennyweights.

§ 4. Hence it is evident, that the ſtrength of the Vena porta ſurpaſſed that of a portion of the Aorta of equal area with it, notwithſtanding the increaſe of ſtrength in this latter, and the loſs of it in the former by age and a longer circulation, in the proportion of 1407 to 1000 nearly.

§ 5. Comparing likewiſe the area of an inch in length of the Vena cava, and the weight incumbent on it at the time of its burſting, with thoſe belonging the Vena porta in the ſame dog, it appears by computation, that the Vena porta would not have broke, had its area been equal to that of the Vena cava, unleſs the weight upon it was equivalent to 73 pounds, 11 ounces, 2 pennyweights, 9 grains.

§ 6. Hence we learn, that the Vena porta was ſuperior in ſtrength to a portion of the Vena cava at the origin of the Emulgent Veſſels in the ſame dog, tho' compared in equal areas together, in the proportion of 1544 to 1000 nearly.

§ 7. An inch in length of the Aorta in Exp. XLII, required the weight of 25 pounds, 1 ounce, 5 pennyweights, 19 grains, to break it. Now this Artery and the Vena porta in this dog were in thickneſs equal to 0.024, 0.0029 of an inch reſpectively, and from Exp. XXXII. § 14. we learn, that the Pericardium and the Pia Mater of the ſame dog were $\frac{1}{413}$, $\frac{1}{1698}$ of an inch thick reſpectively. Hence if we take the Logarithms of theſe thickneſſes, and compare them with the Logarithm of the weight above-mentioned, it is evident, that was the Aorta of an equal thickneſs with the Vena porta, the weight of 3 pounds, 0 ounce, 8 pennyweights, 2 grains, would be ſufficient to break an inch length of it. Now it is evident, that the Vena porta in the ſame circumcumſtances would have required the weight of 35 pounds, 4 ounces, 4 pennyweights, to break it. Laſtly, if we imagine the Aorta reduced to the thickneſs of the two preceeding membranes, we ſhall find its ſtrength in the firſt of theſe inſtances yielding to the weight of 2 pounds, 6 ounces, 7 pennyweights, 20 grains, and in the ſecond to the weight of 7 ounces, 7 pennyweights, 20 grains ½; whereas the firſt of theſe membranes, *viz.* the Pericardium, would upon the ſame terms have required the weight of 38 pounds, 1 ounce, 10 pennyweights, and the latter of them, *viz.* the Pia

Mater, in the ſame Circumſtances, would not have broke, unleſs the weight had been equal to 8 pounds, 4 ounces, 12 pennyweights; that is in this laſt inſtance, more pounds than the Aorta of the ſame dog would ſuſtain ounces, when upon an equality with it, as well with reſpect to ſurface as thickneſs; and this from no other cauſe, but the difference of texture; there being nothing beſides that excepted in the compariſon between them.

§ 8. Hence appears the reaſon of thoſe acute and exquiſite pains, which affect the membranous parts in inflammations and other acute diſeaſes, in proportion to thoſe which affect ſuch as are more lax and flabby, and eſpecially when they are ſo connected to the contiguous parts, as to leave very little room for their extenſion, as is the caſe of the Perioſteum, Pleura, and many others.

§ 9. Hence alſo it appears, why in the ſame diſeaſes, and where the ſame parts in different perſons are affected, the ſenſation of pain ſhall be in one moſt exquiſite, whilſt in the other it is very tolerable, merely on account of the greater laxity in the one, and rigidity and denſity of the membranes in the other. And laſtly, hence likewiſe it appears, why diſeaſes attended with relaxation of the Fibres, are more eaſily relieved in ſuch whoſe Fibres are naturally tenſe and ſtrong, than in ſuch where their texture is lax and yielding, and *vice verſa*: The conſtitution of the ſick in the one promoting, in the other abating the efficacy of the medicines.

EXPERIMENT XLV.

§ 1. The Emulgent Artery being cut off from the Aorta in EXP. XLII, I compreſſed the air in the ſealed top of the Gage with a force equal to that of 5.28 Atmoſpheres, before I was able to produce any leakage or rupture in the coats of this Artery.

§ 2. The diameter of this Artery was 0.035 of an inch; therefore the Logarithm 9.0413927 will expreſs an inch in length of its ſurface, and the weight incumbent on it from the preceeding preſſure will be equivalent to ſo many ounces troy as correſpond to the Logarithm 2.0947163, equal, as appears by computation, to the weight of 10 pounds, 4 ounces, 8 pennyweights.

§ 3. The weight incumbent on the trunk of this Artery, having its area equal to 0.3457 parts of a ſquare inch, was 25 pounds, 1 ounce, 5 pennyweights, 19 grains. Comparing therefore theſe quantities with thoſe belonging the Emulgent Artery of the ſame animal in § 2. of this Experiment, it appears, that had the area of this Artery been equal to that of an inch in length of the trunk it was derived from, it would not have broke, unleſs the weight upon it was equal to 32 pounds, 6 ounces, 18 pennyweights.

§ 4. Hence it is evident, that the Emulgent Artery in this old dog of equal area with the Aorta it ſprung from, was ſuperior in ſtrength to it, in the proportion of 13 to 10 nearly.

EXPERIMENT XLVI.

§ 1. The Emulgent Vein, correſponding to the Artery in the preceeding Experiment, burſt when the preſſure was equivalent to 1.206 Atmoſpheres, but had in the mean time ſuffered a ſmall portion of air to eſcape through its pores.

§ 2. The diameter of this Vein was 0.12 of an inch, and conſequently the Logarithm of its area an inch long, will be 9.5764565, and that of the weight required to burſt it, will be 1.9884935, correſponding to 8 pounds, 1 ounce, 7 pennyweights, 18 grains.

§ 3. The weight required to break the area of an inch long of the trunk of this Vein was by Exp. XLIII, 47 pounds, 10 ounces, 7 pennyweights, 19 grains; hence comparing their reſpective areas and weights together, it is evident, that had the Emulgent Vein been equal in area to the Vena cava, where it receives what the other diſcharges, the weight of 15 pounds, 6 ounces, 15 pennyweights, 14 grains, would have been ſufficient to break it.

§ 4. Hence it is evident, that the Emulgent Vein was exceeded by the Vena cava in ſtrength when compared together in equal areas, in the ſame animal, in the proportion of 3076 to 1000 nearly.

§ 5. The weight required to break an inch in length of the Emulgent Artery, was by the preceeding Experiment equal to 10 pounds, 4 ounces, 8 pennyweights; hence comparing the weight in § 2. which broke an inch in length of the Emulgent Vein, with this, and their reſpective areas together, it appears, that the Artery would not have burſt, had its area been equal to that of the correſponding Emulgent Vein, unleſs the weight upon it was equivalent to 35 pounds, 6 ounces, 6 pennyweights, 19 grains.

§ 6. Hence it appears, that the Emulgent Artery was ſtronger than a portion of the correſponding Vein of equal area, in the proportion of 4378 to 1000 nearly.

§ 7. Comparing the areas of the Vena porta and Emulgent Vein together, and likewiſe the weights required to break them, as they are ſeverally delivered above (*a*), it appears, that the Emulgent Vein upon an area equal to that of the Vena porta of the ſame animal, would break with the weight of 13 pounds, 6 ounces, 6 pennyweights, 19 grains.

§ 8. Hence it is evident, that a portion of the Vena porta of equal area with the Emulgent Vein, was ſuperior in ſtrength to it, in the proportion of 4751 to 1000 nearly.

(*a*) § 2. Exp. XLIV.

§ 9. In comparing the areas of the Arteries and Veins in this old dog, it is evident from the foregoing Experiments, that the capacity of the Vena cava at the Emulgents, is ſuperior to that of an equal length of the correſponding Aorta, in the proportion of 437 to 100 nearly. And the capacity of the Emulgent Vein exceeds the capacity of an equal length of its correſponding Artery, in the proportion of 14400 to 1225, that is, as 1176 to 100 nearly.

EXPERIMENT XLVII.

§ 1. The thickneſs of the Emulgent Artery of this dog was 0.013 of an inch, and that of the Vein correſponding to it was 0.0011 of an inch. The Vena cava at the Emulgents was 0.012 of an inch in thickneſs.

§ 2. Comparing the thickneſs of this Emulgent Artery with that of the Aorta it aroſe from, given in § 7. Exp. XLIV, and their reſpective diameters together, it is evident, that the fluid contained in the cavity of this Aorta, is, to the coat that contains it, in the proportion of 121 to 128 nearly; and the fluid in the cavity of the Emulgent Artery, is, to its reſpective coat, in the proportion of 1000 to 2037 nearly.

§ 3. In like manner it appears, that the fluid contained in the cavity of the Vena cava of this dog at the Emulgents is to the coat of this Vein, in the proportion of 4594 to 1000 nearly; and that contained in the cavity of the Emulgent Vein will be, to its coat, in the proportion of 2702 to 100 nearly. Hence it is evident, that the bulk of the ſolids of that part of the

Vena cava into which this Emulgent Vein empties its contents, is with reſpect to the fluid they act on, ſuperior to the bulk of the ſolids acting on the fluid contained in an equal length of the Emulgent Vein, in the proportion of 167270400 to 28187236, that is, nearly as 593 to 100.

§ 4. The diameter of the Vena porta of the ſheep was 0.49 of an in inch, and its thickneſs 0.0053 of an inch (*a*). Hence it is evident, that the fluid contained in the cavity of this Vein is to the coat that contains it, in the proportion of 2286 to 100 nearly. In like manner the fluid contained in the cavity of the Vena porta of the dog, is ſuperior in bulk to the ſolid that acts upon it, in the proportion of 17 to 1 nearly.

(*a*) § 9. Exp. XLI.

§ 5.

§ 5. Hence it is evident, that notwithſtanding the bulk of the ſolid in the Vena porta in each of the preceeding animals, with reſpect to the fluid it propels, differs but little from that acting on an equal quantity of blood in the Emulgent and Splenic Veins, yet the ſtrength of the Vena porta, as well in the dog as in the ſheep, not only far exceeds that, which thoſe above-mentioned are endowed with, but is likewiſe greatly ſuperior to that of the Vena cava, Aorta and Emulgent Artery reſpectively, notwithſtanding the coats of theſe veſſels are ſo much thicker, and ſo far ſurpaſs in bulk that of the Vena porta acting on an equal quantity of fluid (*a*).

§ 6. I have already ſhewn at § 4. Exp. XV, XVII, § 3, 4. Exp. XXIV,

---

(*a*) § 3. to § 10. Exp. XLI. § 3. to § 8. Exp. XLIV. § 7, 8. Exp. XLVI.

XXV, XXXIV, XXXV, and in many others, too numerous to be quoted here, the great difference of ſtrength in ſeveral branches of the Arteries, with reſpect to the trunks from which they ſpring, and conſequently their action, with regard to each other, on the contained fluids, ſo far as depends on this cauſe; but how far this proportion is carried, is a Problem I ſhall not undertake to ſolve. Tho' it is not improbable, that more light might be gained, even in this dark part of the animal ſtructure, than has hitherto been diſcovered, was it attempted by proper experiments.

That indeed ſuch an increaſed degree of ſtrength, as is found in ſome of the larger ramifications, is propagated thro' the minuteſt diviſions of the Arteries, is by no means probable; but that the ſmalleſt branches have a greater degree of ſtrength in proportion to their ſize, than their reſpective trunks is highly credible ; inaſmuch as the protruſive force of the heart in theſe veſſels muſt be extremely ſmall, for the reaſons above alledged, *viz*. the increaſed capacity or aggregate of the branches in proportion to their trunks, as alſo from their angles and curvatures, and conſequently the circulation carried on much by the lateral impulſe, and the vibrations, they receive from the pulſation of the larger veſſels, which is ſmartly returned upon the fluids contained in theſe minute canals by their own natural ſpringineſs and elaſticity. Nor will this ſeem ſtrange and unaccountable to any one, who conſiders, how agreeable it is to the operation of nature in many other inſtances, where not only the circulation is principally carried on, but ſecretions performed more by the impulſe of the contiguous parts *ab extra*, than from the protruſive force of the heart; as appears moſt evidently in the liver, and its appendage the ſpleen, wherein the alternate Contractions and Relaxations of the Diaphragm, and Muſcles of the Thorax and Abdomen, have the principal ſhare in promoting the operation of theſe two complicated Organs.

That various degrees of Strength are requiſite in the branches, in order to the due performance of each particular ſecretion, ſeems plainly deducible from the various Cohæſion, Denſity, and Strength of the ſecerning Organs, as well as from the different nature and tenacity of the Liquors themſelves. That the branches alſo are endowed with degrees of Strength, differing very much in proportion from thoſe of their Trunks, is ſufficiently apparent from the foregoing Experiments; but what theſe are, or how far from the Aorta this increaſed degree of Strength is carried, cannot eaſily, if at all be determined, becauſe of the extreme minuteneſs of a Capillary Veſſel; tho' it is not improbable, it may be continued in different parts in very different proportions, according to the various uſes for which they are deſigned, poſſibly till the ſecretion is abſolutely perfected in the Gland itſelf; which is uſually formed of various Convolutions and Contorſions of it, as appears by thoſe of the Conglobate kind. Whether this be ſo or not, I ſhall not preſume to determine, but the more firm contexture of theſe, than the other parts of the Secretory Organs, render it not wholly improbable. Nor is the caſe otherwiſe in the Conglomerate kind, which tho' not capable of an equal ſcrutiny thro' their extreme ſmallneſs, appear to be a Congeries of ſuch like Organs wrapt up in one common Tegument, and generally diſcharging themſelves into one common Duct, but always appear more firm and compact in that part, where the Secretion is performed, than any other part of the Viſcus to which they belong.

Nor is this weaker and more eaſily diſtenſible texture the ſole particularity in the ſtructure of the Aorta with regard to others, the whole intermediate ſubſtance betwixt the outward and innermoſt Coat, tho' of an Elaſtic nature, which way ſoever it be drawn or compreſt, having a very different degree of Cohæſion, and being much more brittle and friable than in the Branches, eſpecially ſuch as are at ſome diſtance from it, which are much tougher, and have a greater degree of elaſticity in proportion to their ſize than the Aorta itſelf (*a*). But tho' this ſeems to be the caſe in all the larger Branches with regard to their Trunks, yet it is extremely various according to the different purpoſes, for which ſuch Arteries are deſigned, particularly where any remarkable Secretion is to be made, or the Humors prepared for a ſubſequent preparation, in which caſes they are much ſtronger than elſewhere. Inſtances of which are the Emulgent and Splenic Arteries, which though much ſmaller are vaſtly ſtronger than the Aorta itſelf, when compared in portions of equal Areas (*b*). Which is ſtill further evi-

---

(*a*) § 4. Exp. XV, XVII. § 4, 5. Exp. XXVI.

(*b*) § 3, 4. Exp. XXXIV, XXXVI, XXXVIII, XLV.

dent from § 5. Exp. XXXVI: § 5, 6. Exp. XXXVIII: § 2, 3. Exp. XL. where theſe Arteries are compared with the Iliacs of the ſame Animal, by which no Secretion is made. And indeed, this ſeems neceſſary, of whatever kind the ſecreted Fluid ſhall be ſuppoſed to be. For in caſe a thin Fluid is to be ſeparated from the groſs ſubſtance of the Blood, the remainder, when deprived of its thinneſt parts, muſt require a greater Force and Energy in the Veſſels to propel it into the correſponding Veins. In like manner if we ſuppoſe the Secretion of a Viſcous and Tenacious Humor deſigned, the thin and more fluxile parts muſt firſt neceſſarily be drawn off, before ſuch a ſeparation, and conſequently a ſtrong force will be neceſſary, as well in the Secretory Organ, to ſtrain off, and convey this Humor,

mor, as in the Artery itſelf, which is obliged to convey the Blood thus deprived of its moſt fluid parts, not only to the correſponding Veins, but into the Gland itſelf, which without a conſiderable force it could not enter, but muſt regurgitate and diſtend the coats of the Artery, as is evident to the ſenſes in moſt Chronic Diſeaſes from Diſſections, even to ſuch a degree, that the veſſels themſelves are found frequently burſt near ſuch obſtructions.

But what adds ſtill more ſtrength and light in this matter, is, the ſize and texture of ſuch Veins, as carry the remaining Blood from the Secretory Organs, which are ſo different from thoſe, that ſerve in general only for conveying the Blood back to the Heart, that theſe are as remarkable for their largeneſs, weakneſs, thinneſs and laxity (*a*), as their correſponding Arteries are for the contrary qualities; as appears by the Veins correſponding to the Arteries above-mentioned, *viz.* the Splenic and Emulgent Veins. By which admirable contrivance the reſiſtance to the Artery in performing the Secretion is not only rendered as ſmall as poſſible, but the obſtructions in it, as alſo any impediments to the Secretion from a turgeſcency in the Vena cava, prevented. For if we ſuppoſe, (as muſt often happen either from a long and vigorous exerciſe of the Muſcles, a violent paſſion of anger, or any other like cauſe, by which the motion of the Blood is accelerated) a greater quantity than uſual ſuddenly derived into the Veins, the return of the blood from theſe

---

(*a*) § 3, 4. Exp. XXXVII. § 5, 6, 7. Exp. XXXIX. § 4. Exp. XL. § 3, 4, 9. Exp. XLVI. § 3. Exp. XLVII.

Secretory Organs, would from the increaſed reſiſtance in the larger Veins, ariſing from their Plenitude and Strength of their Coats, be in ſome meaſure prevented, or at leaſt delayed; whence the reſiſtance to the Blood in the Artery, would be conſiderably augmented, its progreſs interrupted, and obſtructions formed in the Capillary Branches, and conſequently the neceſſary Secretions ſtopped or diſturbed.

This ſeems in moſt places to be the deſign of Nature in making the reductory Trunks of theſe Veins ſo weak, large and thin, by which means they are admirably ſuited to the abovementioned purpoſe; becoming as it were a kind of Reſervoir to the returning Blood, till ſuch time as it can be received by the Vena cava without any diſorder in the Animal, or impediment to particular Secretions. But this ſtill appears more plain from the compariſon of theſe Veins, with ſuch, as convey the Blood not immediately from any Secretory Organ, but ſerve only for reconveying it to the Heart in order to a freſh Circulation, as with the Iliac Veins, and Vena cava itſelf, which bear a proportion to their Arteries very different from thoſe correſponding to the Veins above-mentioned, as well with regard to Strength and Thickneſs, as their Size and Capacity (*a*).

Whether this degree of Laxity and Weakneſs be continued to its union with the Branches of the Artery, ſtill remains a ſecret. 'Tis indeed probable it does not, but that it is extremely variable both in its Size and

---

(*a*) § 5, 6, 7. Exp. XXXIX. § 4. Exp. XL. § 3, 4, 9. Exp. XLVI.

Tenſity, according to the different reſiſtance neceſſary to the ſeparation of each particular Fluid, inaſmuch as the more vigorouſly it is propelled by the Artery, and the greater reſiſtance it meets with in the Capillary Vein, the more ſtrongly it will be compreſſed and agitated in the Gland, and *vice verſa*; and conſequently ſuited, by theſe infinite degrees of action, to innumerable Secretions.

Hence we may ſee how by the accidental hurt or contuſion, or other fault of a particular Gland, the moſt miſchievous effects may be produced, even tho' the Juices derived to it, may not deviate from their natural ſtate, as in the caſe of Schirrous and Cancerous Glands, made ſo by caſual hurts or bruiſes; which, if timely eradicated, before the malignancy of the Humor has infected the adjacent Veſſels, are often ſpeedily and ſafely cured without any farther inconvenience, than ariſes from the loſs of the part itſelf, which afterwards is vainly attempted by ignorant Quacks, to the irreparable damage of the Sick.

But though the mechaniſm of the Gland itſelf, as explained above, ſeems ſo neceſſary to its ſtructure, that the Secretions could otherwiſe ſcarce have been performed in any tolerable manner, yet this alone would hardly have been ſufficient for anſwering the deſign, and producing them in a proper quantity, and with their due qualities, without a farther contrivance; by which the ſeveral kinds of Particles, neceſſary for forming that vaſt variety of thin, ſubtile, and tenacious Juices, might likewiſe be determined in greater or leſs proportion to the Secretory Organ.

Now this great deſign is brought about, partly by the different Figures, Denſities, and Velocities of the particles conſtituting the Blood, whereby each kind (tho' kept blended together by the ſuperior force of the Circulation) have a perpetual tendency to fly off at ſome Angles in greater proportion than others, and partly, by that infinite diverſity in the Angles, Flexures, and Degrees of ſtrength in different parts of the adductory Veſſels. By the former of theſe, their Niſus to cohere or fly off by the Branches is increaſed or diminiſhed; whilſt their tendency towards each particular Gland is promoted or reſtrained by the latter, in ſuch degree and proportion, as the all-wiſe Author of Nature ſaw beſt adapted to the uſe and preſervation of each Individual Animal.

From this Inquiry on the foregoing Experiments, and the nature of Animal Secretions, it is not difficult to account for many of their Diſorders, and ſhew how neceſſarily they muſt be altered from their natural State, either by an increaſed or more tardy Circulation of the Blood, than is conſiſtent with the Health of the Animal. For ſuppoſing the force of the Circulation increaſed, it is evident, that many Particles of a groſſer nature, than thoſe uſually ſeparated by any particular Glands, muſt now have their natural direction ſo altered, and their Velocities augmented, as to be detached from the Maſs ſooner than they naturally would be, and by their increaſed Impetus enter Veſſels, which otherwiſe they would not; and conſequently be carried in too great proportion to ſuch Glands, as are deſigned for more fluid Secretions; as is apparent from the high-coloured and turbid urine in Fevers. On the contrary, where the Motion is too much diminiſhed, the Particles forming the more Groſs, Viſcous and Terreſtrial Juices, being neither ſufficiently agitated and attenuated to preſerve a due mixture with the Aqueous, nor propelled with a proper force to paſs the ſmaller Veſſels, will remain in too great quantity in the larger, whilſt the Aqueous, which ſhould ſerve as a Vehicle to the reſt, paſs in too great proportion by the ſmalleſt Collaterals, and there ſtagnate and putrefy, thro' the want of a ſufficient Energy in the coats of the Veſſels; altering thereby both the nature and quantity of all the Secretions, till at length the Diſorder concludes in putting a fatal Period to the whole Animal Syſtem, as is apparently the caſe of ſuch

Valve cannot be placed here on this account. The uſe then of the Valves here placed muſt be, not to ſuſtain this conſtant preſſure, but to prevent the repulſion of the Blood back into the Secretory Organ, when urged by ſome other concurrent force applied *ab extra*; and ſuch is the force of the Muſcles of the Thorax, Abdomen, and Diaphragm, whoſe Contractions and Relaxations alternately compreſs and widen all the Veins of the lower Belly, and would neceſſarily produce this effect, if not prevented by the Valves. Nor is this leſs evident from the Valves in Brutes, which are equally numerous with regard to their Structure, as in Men, and even in theſe Veins, whoſe natural poſition is Horizontal, as is the Vena cava of Quadrupeds. Now the principal deſign here cannot be to take off the conſtant equal preſſure of the ſuperincumbent Fluid, in its return towards the Heart, which in this caſe amounts to very little, ſince the ſame Apparatus is allotted by the wiſe Architect without any variation for the erect poſition of Men, where the preſſure is very conſiderable.

This then muſt be the uſe of the Valves, in the reductory Veins of theſe great Secretory Organs; to which that of thoſe in the aſcending ones, ſeems nearly ſimilar, and equally worthy of the wiſe Author of Nature. Inaſmuch as upon ſtrong and violent motions of the body, in running, leaping, or the like, the Venal Blood muſt have acted in the containing Veſſels, not only with the weight of its whole incumbent Column, as it naturally and neceſſarily does; but with this great weight increaſed at every leap or ſtep in ſuch motions; as appears from the nature of gravity, Hydraulics, and the action of bodies on each other; and conſequently have rendered the loweſt Veins ſubject to Varicoſe Tumors, as they ſometimes are from ſuch violent motions, tho' aſſiſted by the Valves.

For the action of the incumbent weight being here not only the greateſt, but the reſiſtance of the Veſſels leſs than above; however ſmall the Vein may be ſuppoſed, its Coat muſt be acted upon, with the force of the incumbent Column. But this effect is in a great meaſure prevented by the Valves; as every ſuch impulſe of the Venal Blood, can only act in proportion to the diſtance of the Valves from each other, inſtead of that which would otherwiſe be produced by the height of the whole Column.

As I have before ſhewn the reaſon why the reductory Veins from the Secretory Organs, ſhould be more large and lax than others; ſo hence appears the reaſon, why theſe ſhould be endued with contrary qualities; there being an abſolute neceſſity, that the Circulation ſhould be performed in due time, and with due vigour; otherwiſe neither the Secretions themſelves could be perfected, nor even the life of the Animal preſerved, had the common Veins been as large and weak, as thoſe deſigned for the former purpoſes.

The wiſdom of this contrivance is ſtill more evident from the numerous Valves placed in the Lymphaticks, which are here apparently neceſſary on account of the exceeding tenuity of their Coats; which would be in perpetual danger of breaking, eſpecially in the Abdomen, by the ſtrong and frequent action of thoſe Muſcles; was not the preſſure thence ariſing, diſtributed in a due proportion, on every part of theſe tender Coats, by means of numerous Valves. For the contained Fluid, being by means of the Muſcles, preſſed *quaquaverſum*, would recoil towards its ſource, with a force too great to be ſuſtained by the Veſſels without a rupture of their Coats; and thence an Aſcites, and Death of the Animal. But as the caſe now ſtands, they much facilitate its progreſs. For the liquor not being able to recede by reaſon of the Valves, muſt on compreſſion of the Veſſels flow forward, being there leaſt reſiſted. But this is only conſequential of their precluding its receſs on compreſſion, and not properly any action of the Valves. And indeed, in this ſenſe, they may be allowed in theſe and ſeveral other parts to promote the Circulation; but not in the manner ſuppoſed by the Vulgar Anatomiſts, as is above ſufficiently explained.

There are indeed other uſes beſides theſe flowing from this Mechaniſm. For the impulſe on the Fluid from the Heart being here extremely diminiſhed, it was neceſſary, that in every part of its progreſs, its receſs ſhould be prevented by a Valve; otherwiſe upon any Languor or Abatement in the Velocity of the circulating Humors, it would be apt to be reſorbed by the Blood-veſſels, and there increaſe the reſiſtance in the Capillaries; and this at a time when the propelling force was already too deficient to the prejudice of moſt, if not all, the Animal Secretions.

Theſe ſeem to me to be the moſt probable reaſons of the different Texture of theſe weak and thin Veins from others, but if any one ſhall aſſign others more probable and ſubſtantial, I ſhall readily give my aſſent to them. For I ſeek Truth only, and ſhall be glad to meet with it from whatever Quarter it may come.

Nor is this leſs remarkable in the Secretion of the Bile, tho' performed by a Vein: Nature in this caſe having not only endued the Vena porta with an extraordinary Coat upon its entrance into the Liver, where the great Buſineſs of Secretion was to be performed, as Anatomiſts very well know; but has alſo given it a greater degree of Strength than any other Vein in the Body (*a*), which is a mat-

---

(*a*) § 3, 4, 7. Exp. XLI. § 5, 6. Exp. XLIV. § 7, 8, Exp. XLVI.

ter not ſo much as ſuſpected by the moſt accurate. Thus we find by Experiment, that the Vena porta is not only much ſtronger than the Vena cava, but even ſuperior to the Aorta, tho' the Coat of this Veſſel vaſtly ſurpaſſes in bulk, that of the Vena porta acting on an equal quantity of Fluid (*a*); which remarkable Strength in this particular Vein, in different Animals of different Species, above the reſt, cannot be ſuppoſed caſual and accidental, but muſt be deſigned by the wiſe Author of Nature for ſome very remarkable End and Purpoſe; but as nothing is here performed, except the Secretion of the Bile, a Liquor indeed abſolutely neceſſary to the Life of the Animal, it is evident, that this ſuperior degree of ſtrength muſt be allotted for that

---

(*a*) § 5. Exp. XLVII.

purpoſe. And indeed if we conſider the great quantity and variety of Humors, which were here to be collected, in order to form the Biliary Juice, and all theſe neceſſarily to be mixed and perfectly blended together by the joint force of the Muſcles of the Thorax, Diaphragm, and Abdomen, and after that propelled with a ſufficient degree of force for ſeparating ſo viſcous a Liquor as the Bile, it will at firſt ſight appear evident, that a greater ſtrength was neceſſary in this Vein, than in ſuch, whoſe ſole office conſiſts in returning the Blood back to the Heart, where the preſſure of the contained Fluid without any force *ab extra* was to be regarded.

Beſides if we conſider this Vein as deſtitute of Valves, which it could not be ſupplied with in regard to its uſe, which was perfectly to blend and mix together the Juices derived into it, whether brought from above or below, we muſt own a ſuperior degree of Strength was neceſſary on this, as well as the forementioned account. For Valves by dividing the Vein, as it were, into ſo many Cells, do not only ſtrengthen the Coats of the Veſſels in ſuch Parts, as they are placed, but by diminiſhing the agitation of the contained Fluid, render its Impulſes againſt the ſides of the Veſſels leſs capable of diſtending them beyond their proper Dimenſions, by the repeated ſtrokes of the Muſcles ſerving to this purpoſe. And conſequently as on the firſt of theſe accounts they would have been improperly placed in this Vein, by preventing the equable mixture of the Juices diſcharged into it, ſo on the latter, a ſuperior degree of Strength was neceſſary, in order to enable it to perform its destined office, without that aſſiſtance which is frequently allowed to other Veins. So exactly nice is the Balance of the all-wiſe Creator, that every part of this ſo complicated Machine is provided with the moſt apt degree of Strength imaginable, for performing the office allotted to it.

Now, if after the ſeparation of the Biliary Juice, we examine the ſtructure of the Veſſel deſigned for reconveying the Blood back to the Heart, we ſhall find it not a ſmall Vein, but a vaſt Sinus extended near the whole length of the upper-ſide of the Liver, its Diameter being conſiderably larger here, than either before it enter, or after it has left this Bowel. Now it is evident from Hydraulics, that the reſiſtance in Fluids is, *cæteris paribus*, as the altitude of the incumbent Column,

lumn, by which it is conveyed to its Reſervoir, but never increaſes according to the wideneſs of the latter, how broad ſoever it be ſuppoſed; and conſequently this large Sinus, was not only the moſt proper imaginable, to receive ſo great a quantity of Blood, as muſt be returned from this Viſcus, but muſt alſo give the leaſt reſiſtance and impediment to the Secretory Veſſels. For the quantity to be returned being in this caſe very great, and requiring a conſtant agitation of its parts, to preſerve its Fluidity, and prevent its growing Grumous, both theſe intentions could in no wiſe have been anſwered, had it returned by ſo weak and lax a Veſſel as either the Emulgent or Splenic Vein, which muſt ſoon have yielded to this ſuperior weight, but are here ſufficiently provided for by the ſtrength of its Coats, whilſt the reſiſtance to the Secretory Organs is in a great meaſure taken off not only by the ſmall weight of the ſuperincumbent Fluid, but by the capaciouſneſs of the returning Veſſel, which can ſcarce be ever ſo diſtended by the remaining Blood, as to give any conſiderable reſiſtance to it, eſpecially if it be conſidered, how large a quantity of Blood is derived from this Vein into the Heart at every Diaſtole.

§ 7. Hence by the bye appears the reaſon, why in many diſeaſes of the Abdomen, where the Obſtructions in the Glands are recent, and the Veſſels tolerably ſtrong, the frequent concuſſions, and alternate contraction and relaxation of the Abdominal Muſcles neceſſarily attendant on exerciſe, eſpecially on horſeback, ſhould be of ſuch ſingular ſervice in the cure of diſeaſes of theſe Veſſels; while in the contrary ſtate, where they are much weakened by diſtention, the Glands Schirrous, and the Obſtructions inveterate, their ſame degree and kind of motion ſhall occaſion their rupture, bring on an incurable Aſcites, and apparently haſten the Death of the Sick: As alſo why ſtrong and frequent Vomits, violent Cathartics, and the like too forcible medicines ſhould in ſuch caſes produce the ſame effect.

EXPERIMENT XLVIII.

§ 1. The different nature of the Cryſtalline, Vitreous, and Aqueous Humors, together with a ſtrict inquiry into the Anatomical Structure of the Eye, more eſpecially of the Ciliary Proceſſes and Capſula incloſing the Cryſtalline, and the Experiments made by Sir *Iſaac Newton* on the Properties of Light, induced me to draw up ſome

Concluſions with regard to the Theory of Viſion, which appearing to me, more ſatisfactory, than what I had met with in the writers on that ſubject, I deſigned to have added in this place. But finding myſelf preceeded herein by an eminent Pen of a very late Date, I ſhall refer my Reader thither (*a*), where he will meet with the Nature of Viſion deduced from Principles concurring with thoſe I intended to have ſubjoined, and confine myſelf to ſuch Remarks and Experiments, as are left untouched by that learned Gentleman, and may be of ſome uſe in further illuſtrating this difficult point.

§ 4. The weight of both the Cryſtalline Humors taken freſh from the

---

(*a*) Dr. *Jurin*'s Eſſay on diſtinct and indiſtinct Viſion, publiſhed at the End of Dr. *Smith*'s Syſtem of Optics.

Eyes of an Ox, and carefully freed from the Capſula they were included in, was in Air equal to 2 pennyweights, 20 grains, 40 mites. The ſame counterpoiſed in Water 6 grains, 56 mites.

§ 3. But as this ſubſtance is very far from poſſeſſing the ſame degree of Firmneſs throughout, but manifeſtly much ſtiffer and more reſiſting in its middle parts, than elſewhere; I pared off from two other Cryſtallines, taken freſh from an Animal of the ſame Species, their external glutinous ſubſtance, till this greater degree of Firmneſs appeared, the remainder weighed in Air 1 pennyweight, 2 grains, 2 mites, and in Water 3 grains, 36 mites.

§ 4. I found the weight of the Capſulæ including theſe Humors to be in Air equal to 0 grain, 90 mites, and in Water they counterpoiſed 4 mites.

§ 5. Hence it is evident, that the Specific Gravity of the Cryſtalline Humors in § 2. was to Water, in the proportion of 6840 to 6184, that is, as 1106 to 1000 nearly.

§ 6. Hence alſo it is evident, that the Specific Gravity of the Cryſtallines in § 5. was to Water, in the proportion of 2602 to 2266, that is, nearly in the proportion of 1148 to 1000; and conſequently the Denſity of theſe Cryſtallines, whoſe outſide was pared off, exceeded that of thoſe which were entire in § 2. in the proportion of 27 to 26 nearly.

§ 7. It appears from § 4. that the Capſulæ of the Cryſtalline Humors were to Water with relation to their Specific Gravities, in the ratio of 1046 to 1000 nearly. Hence by comparing the Specific Gravity of theſe Capſulæ with that of the Cryſtallines in § 5, and 6, it is evident, that they are exceeded in Denſity by the latter, in nearly the proportion of 1057, 1097 to 1000 reſpectively.

§ 8. That Objects placed before the Eye at different Diſtances might be ſeen ſufficiently diſtinct, there were two things abſolutely neceſſary; *Firſt*, that the Lens thro' which the Rays were to paſs, ſhould change its Figure in proportion to that Diſtance. *Secondly*, that the Rays ſhould undergo a conſiderable degree of Refraction. How well the Architect of this noble Organ has provided in the firſt of theſe reſpects, I have no occaſion to mention, after what Dr. *Jurin* has obſerved upon this Head. And how far Viſion is rendered more perfect as to the ſecond particular, we may gather from the preceeding Experiment, in which the ſuperior Denſity of the

Cryſtalline above that of its Capſula or the Aqueous Humor is clearly ſhewn. For, ſince from the nature of Light, the Refractive Powers of different Mediums, are, *cæteris paribus*, proportional to their Denſities, and the direction of this Refractive Force in any Medium acting upon them, is every-where perpendicular to the Refracting Surface, it is evident, that the Particles of Light will be accelerated or retarded, in the ſame perpendicular direction, according as the power of the Medium conſpires with, or againſt the courſe of their motion, and conſequently had the Rays of Light been tranſmitted thro' Mediums of no greater a Denſity, than that of either the above-mentioned, *viz.* the Capſula or Aqueous Humor, the Incurvation of the Rays flowing from every point of an object in their paſſage thro' ſuch Mediums, would have been equally inſufficient for procuring their union, or diſtinct repreſentation within a proper compaſs of the Retina, as if they had fallen upon it with a great degree of Divergency; whence inſtead of obtaining, as by the preſent Mechaniſm, the moſt perfect view, the ſituation of the object will allow, the Animal could be ſenſible of nothing beſides a glimmering Light attended with the utmoſt Irregularity and Confuſion.

§ 9. The Denſity of Glaſs has generally been aſſumed by the writers in Optics for that of the Cryſtalline Humour. Now the Specific Gravity of Glaſs is to that of Water, as 2.58 to 1, and from § 4. of the preſent Experiment, it appears, that the Denſity of the Cryſtalline, when compared with the ſame Fluid, was nearly as 1.106 to 1. Hence

Glaſs was not only an improper ſubſtitute on account of too great a diſproportion between the Denſities of theſe Mediums, but ſtill more unfit to ſupply the place of this Humor, when we conſider it with regard to the nature of Light, and the laws obſerved by it in its paſſage thro' various refracting Mediums. For the Specific Gravity of the Cryſtalline, being nearly a mean between that of Glaſs and Water, renders it much more adapted to theſe Laws, and the repreſenting the Images of exterior Radiants upon the Retina brighter and more diſtinct than Glaſs itſelf can; inaſmuch as this has been demonſtrated by Sir *Iſaac Newton*, too denſe to make the Angle of Refraction a *maximum*, and Water by its levity refracts as much too little to effect it.

§ 10. Hence alſo appears the reaſon, why the Cryſtalline Humor is not of an uniform Denſity and Conſiſtence thro' all its parts, but grows ſenſibly leſs and leſs compact, as you recede from the Centre towards the Circumference, inſomuch that as the accurate Anatomiſt *Morgagni* has aſſured us, and indeed any one from his own obſervation on the Cryſtallines of Men and other Animals may be convinced, the ſubſtance immediately under its Tunic is of ſo liquid a nature, as to flow out upon making the leaſt inciſion into it. For had its Texture been otherwiſe, or of an equal Denſity and Firmneſs with that, we find in § 6. it has acquired at the Centre, it is evident, that every Contraction and Dilatation of the *Ligamenta Ciliaria* muſt produce the like effect in the Capſula of the Cryſtalline

line Humor; had therefore the action of theſe muſcular Fibres been able to alter its figure at all, they muſt have cauſed an irregular and uneven Superficies in a ſubſtance ſo firm and reſiſting, as that at the Nucleus of this Lens appears to be, and conſequently been deſtructive of that Viſion, for which this part was originally deſigned. But this is intirely prevented by their acting upon a ſubſtance of ſo fluid a nature, and whoſe Particles are ſo looſely connected together, as readily to conform to the proper Curvature, when preſſed with the leaſt force one way more than another.

EXPERIMENT XLIX.

§ 1. Having firſt poiſed a Vial with a narrow neck very exactly in the Scales, I filled it with Water, and found the weight of the Fluid to be

1 ounce, 0 pennyweight, 15 grains, 90 mites. Then having perfectly cleared the Vial from the Water, I found the weight of an equal quantity of the Vitreous Humor of an Ox's Eye to counterpoiſe 1 ounce, 0 pennyweight, 16 grains, 8 mites.

§ 2. Hence it appears, that the Specific Gravity of the Vitreous Humor was to Water, in the proportion of 49608 to 49490, that is, nearly as 10024 to 10000.

§ 3. Hence comparing the Specific Gravity of the Vitreous Humor with that of the Cryſtalline in § 5. Exp. XLVIII, it is evident, that the Denſity of the latter Medium is ſuperior to that of the other, in the proportion of 338511600 to 306775872, that is, in the ratio of nearly 10 to 9.

§ 4. Having by this and the foregoing Experiment found the Specific

Gravities of the ſeveral Humors of the Eye with reſpect to Water, we may hence be enabled to diſcover, what are the real Refractive Powers of theſe Mediums, and conſequently what is the proportion, which the reſpective Sines of the Angles of Incidence and Refraction out of each into the other, muſt bear amongſt themſelves, whatever be the Inclination of the incident Ray. For, ſince by comparing the Denſities of ſeveral Mediums of ſimilar component Parts with the reſpective Sines of the Angles of Incidence and Refraction, Sir *Iſaac Newton* found, that not only the Powers of thoſe Mediums in refracting the Rays of Light were nearly proportional to their Denſities, but that the ſame held true without any ſenſible Difference, in ſubſtances diſtinguiſhed from each other with reſpect to their Specific Gravities, in the proportion of 4400 to 1; it is evident, that the Sine of the Angle of Incidence out of Air into the Aqueous Humor or Water being to the Sine of Refraction as 4 to 3, and the Specific Gravity of the Cryſtalline Humor to the ſame Medium being by § 5. Exp. XLVIII, as 6840 to 6184, conſequently the Sine of Incidence will be to that of Refraction, out of Air into the Cryſtalline, as 14 to 10, or 7 to 5 very nearly. Now the proportion of the Sine of Incidence to the Sine of Refraction in Rays of the ſame denomination, paſſing from one Medium to another, is compounded of the proportion of the Sine of Incidence to the Sine of Refraction out of the firſt Medium into any third, and of the proportion of the Sine of Incidence to the Sine of Refraction, out of that Medium into the ſecond, conſequently by a reciprocal Multiplication of the foregoing Sines, it will be found, that the Sine of Incidence is to the Sine of Refraction out of the Aqueous Humor into the Cryſtalline, in the proportion of 21 to 20 very nearly.

§ 5. No one, that is verſed in Anatomy, will I imagine deny, that the Cryſtalline Humor, together with its Capſula, may be conſidered as a variable Lens, being ſo lodged between the Aqueous and Vitreous, as by means of the Ciliary Proceſſes, to have its Spheroidical Figure conſiderably changed. Tho' this Alteration of the Cryſtalline from a Lenticular to a more Globous Form and the contrary, ſerves to many excellent Uſes, yet as all Refractions to a Focus abſolutely require the Mediums from and into which the Rays are to be refracted by the Lens, to be of a different Denſity from itſelf, ſo the preceeding Experiments, both demonſtrate this Truth, and the great Advantages which muſt accrue to Viſion from a Situation of the refracting Mediums, ſo remarkable in the Formation of the Eye. The Denſity of the Vitreous as it appears to be far inferior to the Cryſtalline, ſo is it very little ſuperior to the Aqueous, yet both of them far exceeding the Denſity of common Air. Hence Homogeneal Rays are not only made to converge much ſooner and more accurately to a Focus, but as Sir *Iſaac Newton* has demonſtrated, the Refraction of Heterogeneal Rays, proceeding in the ſame Line of Direction to a denſer Medium, is greatly augmented or diminiſhed by the Rarity of that, from whence they are tranſmitted, therefore as the Specific Gravity of the external Air to either the Aqueous or the Vitreous Humor is nearly in the reciprocal proportion of 850 to 1, this great diſproportion muſt not only cauſe a much ſtronger Refraction of the Rays upon the Retina, but joined with ſome other properties of thoſe Humors very much contribute to the Certainty and Equality of Viſion. For theſe Mediums not being at any time ſubject to vary in their Denſities, or Refractive Powers, and almoſt, if not altogether incompreſſible, the Rays thus tranſmitted will undergo the moſt equable Refraction, whereas had the Retina been ſituated in a Medium liable to great Alterations, or the ſame Changes with common Air, the Refractions ſo made, muſt have been generally irregular and unequal, and conſequently Viſion rendered very uncertain and precarious.

EXPERIMENT L.

§ 1. By Experiment XLVIII, the Specific Gravity of the Capſula of the Cryſtalline Humor in an Ox's Eye, with reſpect to Water, was found to be in the proportion of 1046 to 1000. Now by the Specific Gravity of the Cornea to the ſame Fluid, taken at a Medium from ſeveral Trials, the difference between the Cornea and the Capſula in point of Denſity could not exceed the $\frac{1}{1021}$ Part. I therefore fixed each of them to the Condenſer, and found that the preſſure required to burſt the Capſula was equal to 1.08 Atmoſpheres, and the Cornea bore the preſſure of 7.7 Atmoſpheres, without breaking, but not without ſuffering ſuch a Stream of Air to paſs thro' its Pores, as prevented its Rupture.

§ 2. Now the Arch of the Cornea from one Canthus of the Eye to the other, was equal in length to 5.28 upon the ſmall diagonal Scale divided into ¼ Inches, and the length of the other Arch interſecting it acroſs the Vertex, was equal to 4.16 in Parts of the ſame denomination. Hence reducing theſe Quantities into Inches, and the Decimal Parts of an Inch, and calling them reſpectively by the literal Characters c and t; this Surface of the Cornea may be conſidered as an Elliptical Area equal to that of a Circle, having its Diameter $=\sqrt{ct}$, whence putting its Periphery equal to p, the Area of the Cornea will be equal to $\frac{p\sqrt{ct}}{4}$, equal as appears from Computation to ſo many Parts of a ſquare Inch, as correſpond to the Tabular Logarithm 0.0326981. Hence the weight incumbent on this Area from the preſſure of 7.7 Atmoſpheres, will be found equivalent to ſo many ounces troy, as correſpond to the Logarithm 3.2498785, that is, to 148 pounds, 1 ounce, 15 pennyweights, 14 grains.

§ 3. The Capſula of the Cryſtalline Humor broke with the preſſure of 1.08 Atmoſpheres, hence it is evident, that had its Area been equal to the Cornea, the weight incumbent on it, at the time of its breaking, would have been equal to 20 pounds, 9 ounces, 7 pennyweights, 2 grains; and conſequently the ſtrength of the Cornea was ſuperior to a portion of the ſame Area of the Capſula, in the proportion of 7129 to 1000 nearly.

§ 4. Hence we may obſerve, that altho' the Cornea ſo far ſurpaſſes the

Capſula of the Cryſtalline in point of ſtrength, yet the Denſities and Refractive Powers of thoſe Membranes are very nearly equal, as are alſo thoſe of the Humors immediately ſurrounding the Cryſtalline, conſequently the Rays of Light in their paſſage thro' theſe Membranes will at the moſt receive no other variation in their firſt direction, than what they would have acquired by being tranſmitted thro' a Medium of the ſame Curvature as at preſent, and of equal Denſity with the Vitreous, which exhibits to our View a wiſe Contrivance for the Security of the whole Organ by this great ſtrength of the Cornea, and that by a Subſtance highly conducing to diſtinct Viſion the principal Deſign of the Eye itſelf.

EXPERIMENT LI.

§ 1. The Cornea of an Ox's Eye, whoſe ſtrength we found in the preceeding Experiment, was equal in thickneſs to $\frac{1}{20}$ of an Inch. The Capſula of the Cryſtalline Humor was $\frac{1}{488}$, and the Retina of the ſame Eye was $\frac{1}{1171}$ of an Inch in thickneſs.

§ 2. Hence it is evident that as the Cornea by § 3. of the preceeding Experiment was ſuperior in ſtrength to the Capſula of the Cryſtalline Humor in the proportion of 7129 to 1000, ſo was it likewiſe in reſpect of thickneſs, in the proportion of 188 to 10 nearly.

§ 3. Hence alſo it appears, that the Retina was ſo exceedingly thin, as to be exceeded in thickneſs by the Capſula, and the Cornea, in the proportion of nearly 24 and 508 to 10 reſpectively.

§ 4.

§ 4. That a Membrane of greater Subſtance, or leſs Tenderneſs than the Retina, could not have anſwered the End ſo well, we may eaſily infer from hence, *viz.* that the Particles of Light being extremely minute, and thence acting with a very ſmall Impulſe, it was abſolutely neceſſary, that the Membrane, on which they impinge, ſhould by its Fineneſs and the Delicacy of its Structure, be ſuſceptible of different Vibrations according to the various Degrees of their Action, and conſequently be extremely thin and tender; otherwiſe no Senſation could have been produced, much leſs could any Compariſon between the Senſations been diſtinguiſhed, all our Ideas acquired by Sight depending upon the Compariſon, which the Mind forms from the different Impulſes of the Rays upon the Retina, and not from any Reflection drawn from the Picture painted upon it. For that all the Knowledge of external Objects, and their mutual Relations cannot be conveyed to the Mind by the Aſſiſtance of this Organ, any other way, but by that above-mentioned, is evident from this Conſideration, *viz.* that there is no Connexion between our Idea of the Magnitude of the Object, and its Picture upon the Retina. Since was there any ſuch Agreement, how comes it to paſs, that in looking at an Object from the diſtance of 14 Feet down to that of 5 Inches, we ſtill judge it of the ſame ſize, tho' it is demonſtrable, that the Angle formed in the Eye at ſeveral Poſitions of the Body viewed within this Compaſs, muſt be double, treble, quadruple, &c. of what it was at the firſt diſtance of 14 Feet? So far is the Mind from forming a true Judgment of Body, and all the various Modes and Accidents it appears under, by what it receives from Viſion, that, without any Injury to Truth, I may ſafely venture to affirm, had Man enjoyed only this ſingle Senſe of Sight, and been left deſtitute of all the reſt, it would have been abſolutely impoſſible for him to have gained the Knowledge of the real Length, Breadth, Thickneſs, Solidity, Magnitude and Diſtance of ſuch Objects, as ſhould preſent themſelves to his View. For to form a right Judgment of moſt of the foregoing Particulars, actual Feeling muſt concur with the Sight, and Experience join with it in them all.

§ 5. Since the Impulſe of an exceeding fine Pencil of Rays, whoſe varicoloured Particles ſtrike the Retina in a particular manner and direction, is, as we have ſhewn in the foregoing Section, the true efficient Cauſe of Viſion; we may hence perceive how far Optical writers have been miſtaken in this Point, when they aſcribe all our Knowledge of the Diſtance, Place, Magnitude, and Situation of Objects to a Reflection drawn by the Mind from the Geometry of the Lines and Angles formed by the refracted Rays upon this Membrane. For that it cannot poſſibly depend upon theſe, is demonſtrable from the Structure of the Eye itſelf with reſpect to the manner of its diſcerning Objects, when brought from an obſcure into a bright and dazzling Light. In this caſe, the Pupil of the Eye is almoſt inſtantaneouſly contracted, and till this is done in a ſufficient manner, neither the Diſtance, Situation or Magnitude of the Object can be at all diſcovered, as is abundantly confirmed by Experience. Now nothing is hereby altered with reſpect to the Lines and Angles drawn upon the Retina; but the Quantity of Rays, which would otherwiſe illuminate each Phyſical point of it, are very much ſo, being diminiſhed by the Contraction of the Uvea, in ſuch a Proportion, as is neceſſary to give that Vibration to its Fibres, which is proper for a diſtinct Repreſentation of the Object without either Confuſion or Senſe of Uneaſineſs to the Animal, either of which would have rendered the Deſign of the whole Structure ineffectual.

§ 6. Having in the foregoing Sections examined into the Structure of the Retina with reſpect to its Subſtance, and ſhewn, how neceſſary its extraordinary

Thinneſs was to Viſion, and the forming thence a true Judgment of external Objects; I cannot finiſh theſe Remarks without taking notice of another Particular relating to it, *viz.* the Concave Spheroidical Figure of this Membrane. This is a Circumſtance little regarded indeed by thoſe who have wrote on this Organ, out of an Opinion, that this Figure was merely accidental, in conformity to the Sphericity of the Eye itſelf, and not the Effect of Skill and Deſign. But that the Figure beſt ſuited to anſwer the Purpoſe of the wiſe Architect, by allowing the moſt diſtinct and perfect Repreſentation poſſible of any Object, ſhould be the Effect only of Chance and Accident, ſeems too haſty a Concluſion, with regard to the exquiſite Art and Contrivance, uſed in the Formation of this wonderful Machine. For allowing the Globular Form of the Eye to be undoubtedly the beſt, and given it for its ready Motion in all Directions, this is no Reaſon, why the Expanſion of the Optic Nerve might not have been formed into a Membrane extended within this Orb, after the ſame manner as the Tympanum is in the Ear, had the Rays of Light naturally fallen with equal or greater Advantage on a flat Superficies. But ſo oppoſite would ſuch a Structure of the Retina have been to the due Reception of the Rays of Light, that had it been formed into any other Figure, beſides the preſent, that alone would have rendered the Action of all the other Parts of this Organ very often confuſed, and always imperfect.

For let the circular Arch *AVD* Fig. I. repreſent the poſterior Surface of the Capſula of the Cryſtalline Humor, *C* its Centre, *F* that Point in the Axis *CV* prolonged, to which all ſuch Rays of an external Radiant are refracted as fell infinitely near the Perpendicular one at the Vertex of the Cornea after their Paſſage thro' this Membrane, the Aqueous Humor and the anterior Surface of the Cryſtalline, and from which they may be again conſidered as proceeding towards the poſterior Surface of the ſame Medium in innumerable Directions. Suppoſe one of theſe Rays to impinge on the Curve Surface *AVD* in the Direction *FI* near the Vertex *V*, then from the Point *I* let fall the Perpendicular *OI* upon the Axis *VC*, interſecting it in *O*, and joining the Points *I* and *C*, the Line *IC* will, from the Contraction of the Evoluta of the Circular Arch *AVD* into one Point *C*, be a Ray of the Evoluta. Hence calling the known Quantities $VC=a$, $FV=g$, the unknown, OI the Semiordinate $=y$, the Abſciſs $Vo=x$, and the Focal diſtance from the Vertex $V=f$, we ſhall by the Method of Fluxions obtain the Fluxion of the Incident Ray equal to $\frac{y\dot{y}+g\dot{x}+x\dot{x}}{\sqrt{yy+gg+2gx+xx}}$, and the Fluxion of the Refracted Ray equal to $\frac{y\dot{y}-f\dot{x}+x\dot{x}}{\sqrt{yy+ff-2fx+xx}}$. But it is demonſtrable from the Doctrine of Cauſtics, that the Fluxion of the Incident Ray is to the Fluxion of the Refracted Ray, as the Sine of the Angle of Incidence is to the Sine of the Angle of Refraction, and by § 4. Exp. XLIX, when the Rays of Light paſs from the Cryſtalline Humor into the Vitreous,

treous, it appears, that the Sine of the Angle of Incidence was to the Sine of the Angle of Refraction as 20 to 21, or as s to r, therefore

$$\frac{y\dot{y}+g\dot{x}+x\dot{x}}{\sqrt{yy+gg+2gx+x^2}} : \frac{f\dot{x}-y\dot{y}-x\dot{x}}{\sqrt{yy+ff-2fx+xx}} :: s : r.$$

Now the Equation of the Curve being $yy=2ax-xx$, $y\dot{y}$ will be equal to $a\dot{x}-x\dot{x}$, and conſequently by equal Subſtitution, we ſhall have

$$\frac{g\dot{x}+a\dot{x}}{\sqrt{2ax+2gx+gg}} : \frac{f\dot{x}-a\dot{x}}{\sqrt{2ax+ff-2fx}} :: s : r;$$

whence multiplying the Terms of this Analogy for an Equation and dividing by the Fluxionary Quantity $\dot{x}$, it will be reduced to

$$\frac{sf-sa}{\sqrt{2ax-2fx+ff}} = \frac{rg+ra.}{\sqrt{2ax+2gx+gg}}.$$

But ſince by the Suppoſition, the Focus here ſought is that, which is made by the Coincidence of ſuch Rays as fall near the Vertex V, let the Quantity x be ſuppoſed to vaniſh; and then the Equation will in that caſe become $\frac{sf-sa}{\sqrt{ff}} = \frac{rg+ra}{\sqrt{gg}}$; and conſequently after due Reduction the Value of the ſought Quantity f will be found equal to $\frac{asg}{sg-rg-ra}$. Draw now thro' the Points V and C (the Vertex and Centre of the refracting Curve) the indefinite right Lines VE, CG, parallel to each other, and perpendicular to the Axis VC; and from the Focus F draw the right Line FB, interſecting the Tangent VE in B, and the Radius produced in G. In CG produced take $C\gamma$ to CG, as the Sine of the refracted Angle is to the Sine of the Angle of Incidence, that is, as r to s, then from γ thro' the Point B draw the right Line γf, meeting with the Axis CV produced in the Point f, join the Points G and f, and thro' the Point B draw Bd parallel to Gf. Now from the foregoing Conſtruction it appears, that $CG\text{-}Ve \left(\frac{ssg-asr-srg}{ar+rg}\right) : Ve \left(\frac{ssg}{ar+rg}\right) :: fG\text{-}fV\,(a) : fV = \frac{asg}{sg-rg-ra}$, which being equal to the Value of fV found above, it is manifeſt, that the Rays of Light diverging from the luminous Point F, and impinging near the Vertex V of the Curve Surface AVD, are after their Refraction by the Vitreous Humor collected in the Focus f. Let now HT be a Tangent to the Curve in the Point H, FH an Incident Ray, and Hf the Refracted one as found above. Suppoſe Fh another of the Incident Rays diverging from F, and impinging on the Refracting Curve AVD in the Point h, in the Direction Fh infinitely near to the former Ray FH. Draw HL and

HP perpendicular, and *LT* and *TP* parallel to *FH* and *fH* reſpectively, interſecting the Axis *FC*, and the Tangent *HT*, in the Points *L* and *T*, and from the Centre *C* thro' the Point of Concurrence *P* draw the Line *PC*, and produce it till it meets with the Refracted Ray *fH* in the Point φ. Laſtly, produce *Fh* till it meets with *HL* in the Point *R*, and from the Point *h* of the Curve to the Point φ, draw $h\varphi$, and from the Centre *C*, let fall upon *FH* and *Hf* the Perpendiculars *CQ*, *CS*, interſecting *Fh* and $h\varphi$ in the Points *q* and *s*. Now becauſe the Points *H* and *h* are ſuppoſed infinitely near each other, it is evident, that the infinitely ſmall Arch *Hh* may be eſteemed as a ſtrait Line, coinciding with the Tangent *HT*, and the Triangles *HRh HLT*, and *Hth HPT* as ſimilar; whence we have $C\mathcal{Q} : CS :: qC : sC$. But by the Property of Refraction $C\mathcal{Q}$ is to CS as s is to r, therefore qC muſt alſo bear the ſame Proportion to sC, as the Sine of the Angle of Incidence does to the Sine of the Angle of Refraction. Now the Difference of the Lines Cq and Cs from real Perpendiculars let fall from the Centre C upon the Lines Fh and $h\varphi$, is infinitely ſmall, therefore they may with ſufficient Accuracy be ſubſtituted for the true; and conſequently the Concourſe of all ſuch Rays as Fh, which lay in the Plane of the Triangle FHf, will meet in the Point φ. But it was ſhewn above, that all thoſe Rays which are ſituated in the Conical Superficies generated by the Revolution of the Triangle FHf about the Side Ff, are collected in the Point f, therefore it is manifeſt, that the greateſt Quantity of Rays will naturally after their Refraction thro' the Vitreous Humor fall upon that Part of the Diacauſtic Curve, which lies between the Points *f* and φ, for inſtance near the middle at the Point *c*. Now it is evident, that what we have here demonſtrated of Rays iſſuing from the luminous Point *F* given in any Image formed by the Union of the Refracted Rays, which are tranſmitted from every Point of an external Radiant thro' the Aqueous and anterior Surface of the Cryſtalline Humors, is equally true of any other Point in the ſame Image under the like Reſtrictions; therefore by comparing the Figure of the Refracting Surface *AVD* with the Proportion, which the Sines of the Angles of Incidence and Refraction muſt always bear to each other, as given above, it neceſſarily follows, that the whole radiant Surface will after the complete Refraction of its Rays thro' all the Humors of the Eye be then repreſented in the moſt lively and effectual manner, when its Image is delineated on a Curvilineal Surface Concave towards the exterior Portion of the Capſula of the Cryſtalline Humor, and paſſing thro' the extreme Point of the Axis of the Vitreous.

§ 7. Hence we may plainly perceive, how far the natural Eye exceeds the artificial one, as ſome Authors have named the *Camera obſcura*, even in the manner, in which the Images of their reſpective Radiants are received. For ſince in the latter Machine, the common Baſis of the Rays after their Refraction is a Plain Surface, it is manifeſt, that the Repreſentation of the Object upon it, muſt ſuffer in theſe three reſpects. *Firſt*, The Image muſt be imperfect, inaſmuch as it is demonſtrated in the foregoing Section, that only one Cone of Rays out of all that vaſt Number, which continually flow from the Object, can be exactly terminated in that Plane, all the reſt either falling ſhort, or naturally exceeding the Bounds fixed for their Reception. *Secondly*, The natural Divergency of the Rays being greater, than if they were received on a proper Curve, the Picture formed by them will be more indiſtinct; and *Thirdly*, from both the former Cauſes, its Light or Brightneſs will be much diminiſhed. Now theſe Defects are only ſuch, as attend the Repreſentation of an Object on a Plane, where the Diſtance, Situation, and Magnitude of the one are adapted to the Poſition of the other, in the beſt manner poſſible. But how ſmall and faint a Reſemblance does ſuch a limited Inſtance, as the foregoing, bear to that immenſe Variety, which daily preſent themſelves before the Organ of Viſion! For here, tho' the Rays which impinge on the Retina, flow almoſt every Moment from Objects infinitely diſtinguiſhed from each other in all the foregoing particulars, as well as many other reſpects, yet are they received upon it with ſuch Order and Exactneſs, by falling on the proper Curve, that the Images thence formed appear not only accurately true, (as far as the nature of Refracted Light will admit) when brought under the ſtricteſt Examination of Reaſon and Geometry (*a*); but give in Fact, the ſtrongeſt Proofs of a ſurpriſing Regularity and Diſtinct-

---

(*a*) See § 6. foregoing.

neſs, by affording the Animal that clear and ready Perception of all thoſe ſingular Differences and innumerable Relations, either naturally eſſential to, or accidentally belonging that Multiplicity of Objects, they here reſpectively repreſent. Whereas on the contrary, had the Expanſion of the Optic Nerve been formed into a Membrane of a flat Superficies, and this ſubſtituted inſtead of its preſent Concave Spheroidical Figure, ſo far would the Rays flowing from a like numberleſs Series of external Radiants be from forming upon this ſuppoſed Plane, a Repreſentation of equal Beauty and Uniformity with the preceeding, or that delineated on the Curvilineal Surface of the Retina, that it is evident from the foregoing Section, the principal Foci could not ſo much as once have been collected in their true and proper Place, and conſequently the Impulſe of the Rays being thus rendered irregular and uncertain, moſt of the Ideas, which the Animal could have acquired by the Uſe of this Organ, muſt have been ſo indiſtinct, confuſed, and imperfect, as inſtead of conducing both to its Safety and Convenience, very frequently be the means of leading it into Error, and ſometimes perhaps to its Deſtruction.

EXPERIMENT LII.

§ 1. The Reſiſtance, which ariſes ſolely from the Coheſion and Tenacity of the Particles of any Fluid, being as the time, the Body takes up in paſſing thro'; it is evident, that if a given Ball be ſuppoſed to fall from Reſt in two Fluids of equal Denſities, but unequal Viſcidities, the Times of its deſcent thro' thoſe Fluids compared together, will give the Degree of Reſiſtance, which is occaſion'd by the adhering Particles of one Fluid above thoſe in the other. Now it is evident from Exp. XLIX. that the Vitreous Humor with reſpect to its Specific Gravity differs very little from common Water, but is apparently more glutinous and viſcid. Hence tho' the greater Loſs of Motion, which a heavy Body would undergo in ſurmounting the Reſiſtance of this Humor from the mere Tenacity of its Particles, above what it would in Water, might be found by its Deſcent in each, was its Fall continued to a conſiderable length, yet as that is impracticable, I ſhall endeavour to aſcertain it in the following manner.

§ 2. A piece of Lead, which weighed in Air 3 pennyweights, 0 grain, 27 mites, counterpoiſed in Water 2 pennyweights, 17 grains, 90 mites; then taking the pure Vitreous Humor from an Ox's Eye with as little Agitation as poſſible, I immerged it into this, and found the Weight which kept it in Æquilibrium to be 2 pennyweights, 17 grains, 21 mites.

§ 3. Hence we may obſerve that the Coheſion of the Vitreous Humor of an Ox's Eye is ſuch, that the Weight loſt by a heavy Body as Lead upon its Immerſion into it, above what it would loſe in Water, ſurpaſſes the Weight of what it ought to loſe in this Fluid, above what it does in Water, on account merely of the ſuperior Specific Gravity of this Humor, in a Proportion greater than that of 45 to 1; and conſequently the Specific Gravities of Bodies equal in Bulk being to one another in the ſame Ratio with their abſolute Weights, it is manifeſt from the Compariſon of this and the preceeding Section with § 2. Exp. XLIX, that the Coheſion of this Humor will diminiſh the Weight of any heavy Body immerſed in it, or promote its Suſpenſion therein, juſt as much as if its Specific Gravity with reſpect to Water, had been increaſed almoſt $\frac{1}{9}$ of what it at preſent is, in its natural ſtate.

§ 4. That ſo great a Degree of Coheſion as the Vitreous Humor is poſſeſſed of, above what is allotted to the Particles of Water, cannot be given it with any Deſign to retard the Motion of Light in its Paſſage thro' this Medium, ſeems obvious from the Nature and Intent of Viſion; and that the Rays do not meet with any Obſtruction on this Account, is demonſtrable from the Path which they deſcribe by the Refraction of this Humor, as has been already ſhewn at

§ 6. Exp. LI. But why a more perfect Fluid, of equal Denſity and Refractive Power with the Vitreous Humor, might not have been ſubſtituted in its Place, is a Queſtion not eaſily reſolved. To me the moſt probable Reaſons for this Mechaniſm ſeem to be theſe. *Firſt*, That had the Vitreous been leſs Viſcous, the Cryſtalline could not have remained in the ſame Poſition, and with the ſame Steadineſs as at preſent. For either the Specific Gravity of this Fluid muſt have been conſiderably augmented, which we have already ſhewn at § 5. Exp. XLIX. inconſiſtent with Viſion; or the *Ligamentum Ciliare* muſt have been formed with a much greater Degree of Strength. But this Increaſe of Strength in theſe Fibres would have been attended with an Inconvenience equally deſtructive to Viſion with the former. For upon every Contraction of the Longitudinal Fibres of this Muſcle, the Capſula of the Cryſtalline would indeed have been drawn outwards, but then the Cornea muſt have been drawn inwards, the conſequence of which Action would have been this, that whilſt one was fitting the Organ for the View of near Objects, the other was putting it in a State for ſeeing ſuch as lay at a remote Diſtance. Whereas by thus increaſing the Tenacity of the Vitreous Humor without augmenting its Denſity, the Refraction of the Rays of Light is preſerved equable and undiſturbed, and the *Ligamenta Ciliaria* have ſtrength ſufficient to extend ſo thin and tender a Membrane as the Capſula of the Cryſtalline, without being capable of exerting any Force that can poſſibly at the ſame time contract ſo ſtrong and thick a Tunic as the Cornea, into which theſe Fibres are likewiſe inſerted.

This Viſcoſity of the Vitreous Humor ſeems alſo neceſſary for preventing that inteſtine Motion of its Particles, which upon the Motion and Changes thereby made in the Eye, muſt have been conſequent to ſo thin a Fluid as Water, or the Aqueous Humor, and conſequently whatever Direction the Rays of Light have acquired by their Refractions in the Cryſtalline, that muſt be preſerved without the leaſt Alteration of their Courſe by any Agitation this Fluid can be expoſed to from the ordinary Motions of the Animal, till they impinge on the Retina with that Order, which is neceſſary to diſtinct Viſion.

EXPERIMENT LIII.

§ 1. In order to take the Dimenſions of the Eye of an Ox, I placed it on a Horizontal Board, and applied three moveable Silk Threads, which were kept extended by ſmall Plummets, ſo as to be exact Tangents to the Arch of the Cornea, as well at each Canthus, as at the Vertex, then applying a very exactly divided Scale, I found that the Chord of the Cornea was equal to 1.05 of an Inch, the verſed Sine of this Chord to be 0.29, and conſequently the Radius of the Cornea was equal to 0.620215 of an Inch.

§ 2. I then carefully took off the Cornea, and replaced the Eye as before, and found by applying one of the Threads as a Tangent to the Vertex of the Cryſtalline, that the Diſtance between this and the Vertex of the Cornea was 0.355 of an Inch. Afterwards I took the Cryſtalline out without injuring its Figure, or diſplacing the Capſula, and then applying the

Threads to each Surface of this Humor, as was done before to the Arch of the Cornea, I found that the Chord of the Cryſtalline was 0.74 of an Inch, and its verſed Sine with reſpect to the anterior Surface to be 0.189 of an Inch, and conſequently the Radius of this Surface was 0.45665 of the ſame. In like manner the verſed Sine to the ſame Chord with reſpect to the poſterior Surface of the Cryſtalline I found to be equal to 0.266 of an Inch, and therefore the Radius to this Arch will be equal to 0.38845 of an Inch. Laſtly, I found the Axis of the Cryſtalline, and that of the whole Eye from the Cornea to the Retina to be 0.575. 2.21 of an Inch reſpectively.

§ 3. Hence it appears from the Conſtruction that an Ox's Eye may fitly enough be repreſented by Figure II. in which *ACB* repreſents the Arch of the Cornea, *ASB* the Sclerotica, joining the Cornea in *A* and *B*, *Aa Ba* the Uvea, *aa* the Aperture of the Pupil, *scs* the anterior Surface of the Capſula of the Cryſtalline Humor, *ses* the poſterior Surface of the ſame Lens, *eV* the Axis of the Vitreous Humor, *nd*, *nd* the *Ligamenta Ciliaria*, and *Rr* the Expanſion of the Optic Nerve *O N*.

§ 4. As the Diſtance and Poſition of Objects before the Eye admit of all poſſible Variation, it is plain, that the Focal Diſtances of the Eye from the Cornea to the Retina, muſt vary with the Multitude of Objects preſented to it, and conſequently the Proportions laid down in the preceeding Sections are not ſuch, as are always permanent and immutable, but are rendered ſo far relative by tranſmitting the Images of exterior Radiants, that the Eye can ſcarce one Moment remain the ſame in Situ as before.

§ 5. Hence in all probability aroſe that Error ſo commonly met with in Optical and Anatomical writers, relating to the Cryſtalline and Vitreous Humors, *viz.* in aſcribing a frequent Change of Place to the one, and of Denſity to the other. For they perceiving a mutable Focus to be thus indiſpenſably neceſſary, too eaſily concluded, it muſt be effected by one or both of theſe means. But this Solution will by no means hold good for the following Reaſons: *Firſt*, Whoever duly examines the Compact Figure and Texture of the Eye, will find himſelf under a Neceſſity of concluding, that no ſuch Motion, as is above aſcribed to the Cryſtalline, can be performed by a Body of that Bulk, within Cavities ſo exactly filled, as thoſe of the Eye are. *Secondly*, To procure, or ſuppoſe any Change in the Vitreous or Aqueous Humors from a Compreſſion how great ſoever, amounts almoſt to an Impoſſibility, ſince the Capſula's in which they are included, are capable of an eaſy Contraction and Dilatation. *Thirdly*, Becauſe by the Hypotheſis theſe Medium's muſt be ſubject to frequent Change both of Figure and Poſition; and conſequently their Particles would be in a perpetual undulating State. To convey therefore any diſtinct Image by Rays tranſmitted thro' Mediums of equal Denſity with theſe Humors, and liable to theſe Accidents, is not only demonſtrable from the Nature of Light and known Laws of Refraction impoſſible to ſucceed, but is in Fact confirmed by the Experiment of the Diving Bell, in which its great Improver,

prover, the learned Dr. *Halley*, aſſures us, that notwithſtanding he with ſome others enjoyed a ſufficient Quantity of Light when under Water, by the help of a ſtrong Convex Lens, fixed for the Reception of the Rays at the Head of the Machine, whilſt it remained calm and ſerene, yet whenever by any Accident the ſuperincumbent Fluid was diſturbed, or put in Agitation, the Rays ſuffered ſo much in their Paſſage by ſuch Irregular Refractions, as to throw them into Confuſion and Darkneſs. How vague then, and indeterminate muſt the Focus of thoſe Rays have been, whoſe Refractions were to be effected by Mediums ſubject to ten thouſand Accidents, and I make no doubt, that, had the Eye been ſo conſtituted, upon taking a Review of the ſame Perſons and Things, the

Scene would appear quite altered, and too often force the Spectator to complain in the Language of the Poet (*a*),

Mille hominum Species, & Rerum diſcolor Uſus.

But as the Compreſſion of the Vitreous Humor is ſo generally inſiſted on by the Writers on this Subject, tho' I was fully ſatisfied from the Dilatability of the containing Parts, and the ſmall Force of the Muſcles applied, that it was altogether impoſſible, it could be compreſt into a leſs Space by their means, yet to put the matter beyond all Doubt, I made the following Experiment.

I put the Vitreous Humor of an Ox's Eye into a Syphon Hermetically ſealed at one End, then fixing the Condenſer to the other, I compreſt it with all the Force I was able to give,

---

(*a*) Pers. Sat. V.

and this without any more Effect, than if I had applied the Force to Water, which as every one knows, has not yet been found to give way to the greateſt Preſſure. Whether this Humor may be equally incompreſſible with the above-mentioned, I cannot affirm, but this I am ſure of, that a hundred times the Strength of the Muſcles ſuppoſed to produce this Change in it, would have no ſuch Effect.

§ 6. Another very conſiderable Variation in the foregoing Dimenſions, without which, Viſion in many caſes could not poſſibly be obtained, ariſes from the muſcular Structure of the Uvea *Ba*, *Aa*; in conſequence of which, the Aperture of the Pupil *aa* is increaſed or diminiſhed, according as the Contraction is made by the ſtrait or circular Fibres which compoſe this Membrane. Simple and obvious as this Contrivance of changing the Orifice, through which the Rays of Light were to be tranſmitted to the Retina, may appear, yet has its principal Uſe and Deſign been overlooked, and a fictitious one aſcribed in its ſtead, *viz.* the Power of altering the Projection of an Object upon the Retina, ſo as to change its apparent Magnitude. But this Effect is abſolutely inconſiſtent with the Mechaniſm employed in the Formation of the Pupil. For the Magnitude of the Picture upon the Retina is longer, or ſhorter in Proportion to the Angle made by the two Rays, which proceed from the Extremities of the Object to the Eye. In every Contraction therefore of the Circular Fibres of the Uvea, the Pupil will ſtill remain the Baſis of each Cone of Rays, that can fall upon it from every Point of the Object; conſequently the narrowneſs of the Aperture may obſtruct the Paſſage of part of the Sides of thoſe Cones, and thereby render the Object more or leſs bright, but can never change the apparent Magnitude of a given Object, ſince that will ſtill be in the reciprocal Ratio of its Diſtance from the Eye, as well after, as before the Contraction of the Pupil.

§ 7. Having thus proved that the apparent Dimenſions of any Object are tranſmitted to the Senſorium with the ſame Accuracy and Exactneſs, however its Light or Brightneſs be increaſed or diminiſhed by the different State of the Pupil; we cannot but obſerve under how miſerable a Condition every Animal, and particularly the Human, muſt have laboured, had the contrary Suppoſition prevailed, or the

the apparent Magnitude of the Object been as the Latitude of the Pupil. For by the many unavoidable and neceſſary Changes in this Aperture of the Eye, all our Ideas of Things and their Relations to each other, muſt have become ſo vague and indetermined, that we ought not to wonder, if what at one time appeared to a Spectator, with all the Magnificence of a Palace, ſhould afterwards to the ſame Perſon from no other Change, but a more contracted Pupil ſeem ſhrunk into the ſcanty Limits of a beggarly Cottage: The natural conſequence of which would be, that finding himſelf thus expoſed to perpetual Deluſion and Uncertainty, he would often be at a loſs how to proceed, and being fully ſatisfied, that he could place no Truſt or Security in the Uſe of this particular Senſe, would very probably at laſt doubt of all the reſt, and thence conſtitute ſome humorous Opinion, like that of the Poets, the ruling Principle of all his Actions, *viz.* that,

> Πάντα γέλως, καὶ πάντα κόνις, καὶ πάντα τὸ μηδὲν
> Πάντα γὰρ ἐξ ἀλόγων ἐστὶ τὰ γιγνόμενα.

§ 8. From the Structure of the Eye itſelf, the manner in which it does, and muſt act, if it anſwer the Ends of its Formation, as at large delineated and explained above (*a*) we are furniſhed with an undeniable Argument in Oppoſition to the Sentiments of ſome Philoſophers who have aſſerted the Rays of Light to be equally diffuſed thro' the whole Syſtem of Nature, not neceſſarily emitted from the Sun, but always preſent in a conſtant and invariable Quantity. A Doctrine

---

(*a*) Compare § 5, 6, 7. Exp. LI. with § 5, 6. preceeding.

ſo repugnant to the Nature of Light, the known Laws of Refraction, and the manner in which it is tranſmitted to the Retina, that I ſhould not have taken any Notice of it here, had it not of late Years been ſtrenuouſly eſpouſed and defended by ſeveral excellent Writers, and in particular, by the Learned *Boerhaave*, in his Treatiſe of Chymiſtry; in which the Reader finding many noble Truths, might the more eaſily ſwallow down Error, when diſguiſed *Specie Veri*. For if this Suppoſition was true, all that curious and delicate Mechaniſm, which we ſo juſtly admire in the Formation of the Eye, would for the two following Reaſons anſwer no End or Purpoſe.

Firſt, Since by the Hypotheſis, the Rays of Light are little Corpuſcles every-where floating in the vaſt Regions of Space; whenever we ſuppoſe any Parcel of them to be put in Motion, let the Cauſe that impels them, or its Direction be what it will; that Impulſe will by the 42d Prop. Book 2d of *Newton*'s Princip. be inſtantaneouſly propagated on all Sides and in all manner of Directions, and conſequently the Rays of Light determined after this manner, could neither enter the Aperture of the Pupil, nor the Hole of a dark Chamber in ſtrait Lines, as we are aſſured from the manner in which Viſion is performed, they certainly muſt, and from the Uſe of the Priſm they really do. But this Direction or ſpreading of the Rays of Light *quaquaverſum* upon the leaſt Impulſe or Preſſure, tho' it be an inſuperable Difficulty, yet it is not the only Inconſiſtency, which attends this Hypotheſis in relation to Viſion. For, *Secondly*, What would be ſtill equally deſtructive of it, and prevent the Projection of any Object upon the Retina, (which is placed in a much darker Situation for the due Reception of ſuch Images, than the darkeſt Room contrived by human Art) is this, that the ſmalleſt Hole as well as the greateſt would equally ſerve for the Illumination of a whole Chamber, inaſmuch as a ſingle Pencil of Rays, would, from the Nature of Preſſure communicated to ſuch Bodies, alter the Poſition, and put in Motion all the reſt, that were in a Room tho' of the largeſt Size, of which we have a clear and undeniable Inſtance in the Propagation of Sound, correſponding very exactly to the Motion of Light, as laid down by the foregoing Hypotheſis. I might ſhew ſeveral other Abſurdities deducible from this Scheme, but as they all flow from Experiments, in which Viſion is not the Point in Queſtion, but preſuppoſed, the Relation of them would be foreign to my preſent Purpoſe.

EXPERIMENT LIV.

§ 1. Having placed the Eye of an Ox as in EXP. LIII. beneath a fine Silk-Thread $\frac{1}{10}$ of an Inch diſtant from the Vertex of the Cornea, I fixed others on the lower Edge of the ſame Tunic, ſo as to embrace it as a Sphincter. Hence I found by hanging on Plummets, that to raiſe the Vertex of the Cornea, till it became a Tangent to the forementioned Thread, the Weight required muſt be equal to 3 ounces, 2 pennyweights, 9 grains.

§ 2. This Force in the Eye of an Ox muſt therefore be exerted by the muſcular Ring of the Uvea, in caſe it anſwered the End propoſed by Dr. *Jurin* (*a*); but whether it be capable of exerting ſuch a Force with the greateſt Facility, as it muſt do, if it be ſuppoſed the Cauſe of this Alteration in the Figure of the Eye, on account of its frequent and reiterated Action, is a Point too difficult, I fear, to be determined to an exact Truth, the extreme Tenderneſs of the Uvea, and the Smallneſs of the muſcular Subſtance being too great Obſtacles to be ſurmounted in the Way to it. However the following Experiment will, I hope, put this Matter on ſo good a Baſis, as to render this Opinion, if not abſolutely certain, at leaſt highly probable.

(*a*) See Art. 141, 142. in the Diſſertation on Viſion at the End of Dr. *Smith*'s Optics.

EXPE-

EXPERIMENT LV.

§ 1. Having cleared the Eye of an Ox from all its Humors, I introduced between the Edge of the Uvea and its Juncture with the Cornea a long ſmall Needle, upon which fixing a very light Scale, I found by the Addition of Weights to it, that ¼ of an Inch and 23 Hundredths in Length of this muſcular Ring ſeparated from the Cornea, and broke, when the Weight including that of the Scale was equal to 19 pennyweights, tho' in ſome other Trials, I have known it to ſuſtain above an ounce Troy.

§ 2. Now the Circumference of the whole muſcular Ring, I found to be upon the Diagonal Scale divided into ¼ Inches, equal in length to 12,3 of thoſe Diviſions, and therefore to ſeparate and break the whole Ring from its Connection with the Cornea, the Weight muſt have been equal to 9 ounces, 10 pennyweights, at the leaſt.

§ 3. Since then the greateſt Contraction neceſſary for raiſing the Cornea, as we learn from the preceeding Experiment, was effected by the Preſſure or Weight of 3 ounces, 2 pennyweights, 9 grains, it is evident, that the muſcular Ring of the Uvea is furniſhed with a ſufficient Degree of Strength to procure this Change of Conformation in the Sphericity of the Cornea.

§ 4. By this Contraction of the Cornea, the Rays of Light which would remain after their Refraction thro' the Aqueous Humor in a ſtrong Degree of Divergency, *viz.* ſuch as proceed from very ſmall Objects at ſmall Diſtances, are made to converge in a ſpeedy and effectual manner,

ner, ſo as to paint a diſtinct Image upon the Retina, and ſufficient for the Ends of Viſion. Hence we are enabled to rectify a Miſtake even of the beſt Anatomiſts, in ſuppoſing one of the principal Uſes of the Muſcles allotted this Organ to conſiſt, in giving ſuch a Change to the whole Globe of the Eye, and the Sphericity of its Humors, as thereby to produce the preceeding Effect. For ſuppoſing them capable of any ſuch Action, the Conſequence of it would be directly oppoſite and contradictory to that produced by the *Proceſſus Ciliares* at the ſame Moment of Time. A Fault too great to be committed by the meaneſt Mechanic, and cannot therefore be admitted here.

§ 5. Hence if an Object placed before a Human Eye be ſo exceedingly ſmall and ſubtile, as that in order to make it ſubtend an Angle of one Minute, the leaſt Diſtance, *viz.* 5 Inches at which we ſee an Object with any Diſtinctneſs, muſt be contracted to 3 or leſs, the Conſequence of this would be that the Divergency of the Rays would then be ſo great, that as ſuch minute Objects would not be diſcerned at all, ſo even large ones in the ſame Situation would be ſeen with great Pain and Inaccuracy. This Limitation of Viſion in Man, is ſo far from concluding any Imperfection or Deficiency in the Formation of his Eye, that it proves the direct contrary. For had it been formed only for the diſcerning of Objects poſited at ſo ſmall a Diſtance; not only many that would have been uſeleſs, but even diſagreeable and offenſive to him, would have perpetually preſented themſelves to his View, which by the preſent Structure give him no Diſturbance, but the Sphere of Viſion would have been circumſcribed within ſuch narrow Bounds with reſpect to his Size, that he might rather be ſaid to have groped than ſeen his Way, and could not with any Degree of Safety have moved much faſter than that ſluggiſh Inſect a Snail.

§ 6. Hence alſo appears the Conſtruction and Uſe of the Microſcope, which by making the Diverging Rays fall after Refraction in a Direction nearly Parallel upon the Eye, the Angle, under which the Object is ſeen, becomes ſo inlarged, that if its Magnitude was no more than the $\frac{1}{4000000000000}$ of a Cubical Inch, it may ſtill be brought within the Cognizance of a Human Eye.

INDEX.

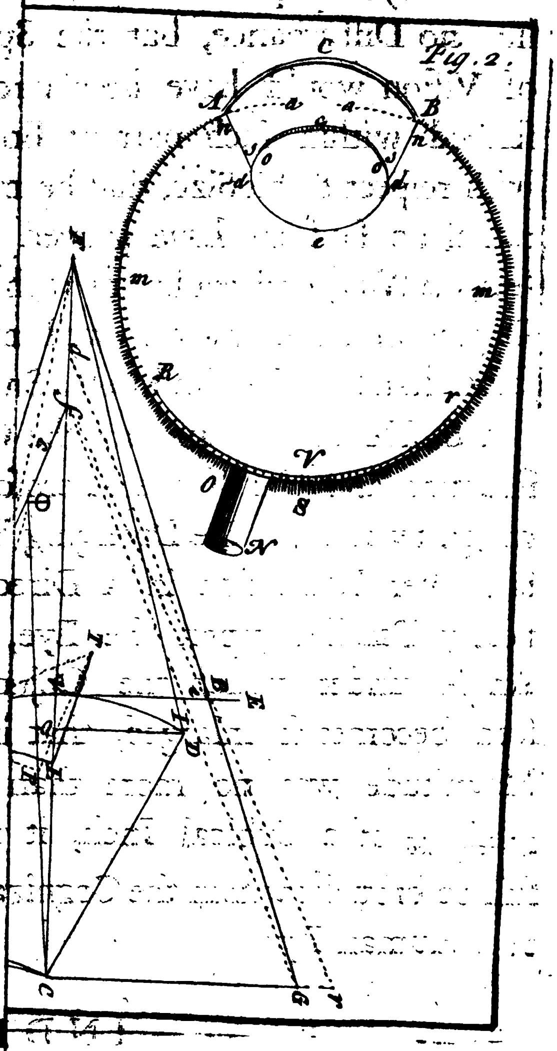


Fig. 2.

INDEX.

THE Theory of Phyſic not free from Obſcurity and Error
To what Cauſe chiefly owing
The proper Remedy aſſigned
The Author's Intent in the following Inquiry
Introduction.

The Aorta deſcendens taken from ſeveral young Animals, its Specific Gravity in each different Species Exp. I. to Exp. V. Sect. 3. Exp. IX. § 3.
The correſponding Veins, their Specific Gravities Exp. I. to Exp. V. § 4. Exp. IX. § 4.
Theſe compared Exp. I. II. IV. IX. § 5. Exp. III. § 4.
The Aorta deſcendens in each of the preceeding Inſtances, its Thickneſs Exp. V. § 1, 2. Exp. XI. § 1.
The correſponding Veins their Thickneſs in each Animal Exp. V. § 1, 2, 3.
Theſe compared Exp. V. § 4.
A Method laid down by which the Thickneſs of Animal Veſſels may be obtained with great Exactneſs Exp. IV. § ult.

The Texture of the Aorta in young Animals conſidered
The Neceſſity of ſuch a Structure to the Continuance of Life to its natural Period
Exp. V. § 5.

The Texture of the Veins generally more compact than that of the correſponding Arteries, and why Exp. V. § 6.
An Objection drawn from the Valves placed in

them conſidered, and ſhewn to be of no Force Exp. V. § 7.

Anatomiſts, their Miſtake in the Definition of a Vein } Exp. V. § 7.
Such a Structure of the Veins ſhewn inconſiſtent with the Life of the Animal } Exp. V. § 7.

The Aorta deſcendens taken from ſeveral old Animals, its Specific Gravity in each different Species Exp. VI. to Exp. IX. § 3. Exp. X. § 3.

The correſponding Veins, their Specific Gravities Exp. VI. to Exp. XI. § 4.

Theſe compared Exp. VI. to Exp. XI. § 5.

The Aorta deſcendens, an Inch in length, taken from a very old Animal, what Weight it ſuſtained at the inſtant of its breaking Exp. XLII. § 2.

Its Thickneſs Exp. XLIV. § 7.

The correſponding Vein an Inch in length tried in the ſame manner Exp. XLIII. § 2.

Its Thickneſs Exp. XLVII. § 1.

The preceeding Articles relating to this Artery and Vein compared Exp. XLIII. § 3, 4.

The Arteries and Veins in old Animals, how altered in their Specific Gravities and in their Strengths, from thoſe of the correſponding Veſſels in young ones of the ſame Species Exp. VI. to Exp. XI. § 6. Exp. XLIII. § 4.

Intemperance and Debaucheries in Youth, productive of the like Changes in the Animal Veſſels, and why Exp. XLIII. § 5.

The Proportion of the Fluid in the Cavity of the Aorta deſcendens in young Animals, to the containing Coat in each reſpectively Exp. XI. § 2.

The

The Proportion of the Fluid in the Cavity of the Aorta deſcendens, in old Animals of the ſame Species, to their reſpective containing Coats Exp. XI. §3.

Theſe Proportions compared Exp. XI. §4.

Nutrition how performed in an Animal Body
The Changes introduced by it conſidered
The Feebleneſs and Tremors obſerved in old Animals to what Cauſe chiefly owing Exp. XI. §5.

The different Diſeaſes incident to young and old Animals, with their Conſequences in each conſidered Exp. XI. §6.

Dr. Keil's *Notion relating to Nutrition examined* Exp. XI. §7.

The Practice of rejecting Venæſection in the Diſtempers of old Perſons, ſhewn to be often unreaſonable and pernicious Exp. XI. §8.

Conſumptions truly habitual, why limited to a Period of forty Years Exp. XI. §10.

The Denſity of the Convex Side of the Aorta deſcendens, in Animals of different Ages and Species, compared with that of the Concave or oppoſite Side of the ſame Veſſel, in each Animal reſpectively Exp. XII. §2, 3.

The Thickneſs of each Part of the Aorta deſcendens in all the foregoing Inſtances Exp. XIII. §1.

The remarkable Structure of the oppoſite Sides of the Aorta deſcendens, both as to Denſity and Thickneſs ſhewn Exp. XII. §2, 3. Exp. XIII. §2, 3.

The Aorta deſcendens, an Inch in length, taken *from a Man at a ſmall Diſtance from the Heart, what Weight it ſuſtained at the Inſtant of its breaking* Exp. XIV. § 2.

An Inch in length of the ſame Artery, inferior to the former in Thickneſs and Diameter, what it ſuſtained at the time of breaking Exp. XV. § 2.

The Thickneſs of the Artery in each Place Exp. XV. § 4.

The Aorta deſcendens of a Boar, above the Origin of the Cæliac Branches, what Weight it ſuſtained at its breaking Exp XVI. § 2.

An Inch in length of the ſame Artery between the Origin of the Emulgent, and Iliac Branches, what Weight it bore at the Inſtant of breaking Exp. XVII. § 2.

The Thickneſs of the Artery in each Part Exp. XVII. § 4.

The Strength and Thickneſs of equal Portions of the Aorta deſcendens, in different Parts of it, compared Exp. XV. XVII. § 4.

The ſuperior Denſity and Thickneſs in the Convex Part of the Aorta deſcendens, above what is found in the Concave or oppoſite Part of the ſame Artery, falſely imputed to the Effect of Age, and the continued Impulſe of the Fluid upon it. Exp. XVII. § 5.

The Reaſon and Neceſſity of this Mechaniſm in the Aorta deſcendens conſidered Exp. XVII. § 5.

Anatomiſts, their Concluſions on the Strength of Arterial Veſſels ſhewn contrary to Fact, and inconſiſtent with the Laws of Animal Circulation Exp. XVII. § 6.

The Specific Gravity of the Aorta deſcendens in a Ram near the Origin of the Emulgent Arteries Exp. XVIII. § 3.
The Weight required to break an Inch length of it Exp. XX. § 2.
Its Thickneſs Exp. XXVI. § 1.
The Specific Gravity of the correſponding Vein Exp. XVIII. § 4.
The Weight required to break an Inch length of it Exp. XXI. § 2.
Its Thickneſs Exp XXXII. § 1.
The preceeding Articles relating to this Artery and Vein compared Exp. XVIII. § 3, 4. Exp. XXXII. § 3.
The Capacities of this Artery and Vein, each an Inch in length, compared Exp. XXVIII. § 7.
The Specific Gravity of the Aorta deſcendens in a Ram near the Origin of the Iliac Arteries Exp. XIX. § 3.
The Weight required to break an Inch length of it Exp. XXIV. § 2.
Its Thickneſs Exp. XXVI. § 1.
The Specific Gravity of the correſponding Vein Exp XIX. § 4.
The Weight required to break an Inch length of it Exp XXVII. § 2.
The preceeding Articles relating to this Artery and Vein compared Exp. XXVII. § 3, 4.
The Capacities of this Artery and Vein compared Exp. XXVIII. § 7.
The Iliac Branch of the foregoing Artery in a Ram, with what Weight compreſſed at the Inſtant of its breaking Exp. XXV. § 2.
Its Thickneſs Exp. XXVI. § 1.

The correſponding Vein what it ſuſtained Exp. XXVIII. § 2.

Its Thickneſs Exp. XXXII. § 1.

The preceeding Articles relating to this Artery and Vein compared Exp. XXVIII. § 5, 6.

The Capacities of this Artery and Vein, each an Inch in length, compared Exp. XXVIII. § 7.

The Strength of the Aorta, at the Origin of the Emulgent Arteries, compared with that belonging the ſame Veſſel of equal Area, at the Origin of the Iliacs Exp. XXIV. § 3, 4.

The Thickneſs of theſe Portions and their Strength compared Exp. XXVI. § 4.

The Strength of the Iliac Artery, compared with that belonging a Portion of the Trunk it aroſe from, of equal Area Exp. XXV. § 4.

The Thickneſs of theſe Portions and their Strength compared Exp. XXVI. § 5.

The Strength of the Aorta at the Origin of the Emulgents, compared with that belonging a Portion of equal Area and Thickneſs of the ſame Artery, at the Origin of the Iliacs, and of the Iliac Branch, reſpectively Exp. XXV. § 5.
Exp. XXVI. § 5.

The Capacity of an Inch in length of the Aorta, at the Origin of the Emulgents, compared with that of an Inch in length of the ſame Veſſel, at the Origin of the Iliacs, and of the Iliac Branch, reſpectively Exp. XXV. § 6.

The Capacity of an Inch in length of the Aorta at the Origin of the Iliacs, compared with that of an equal length of the Branch Exp. XXV. § 6.

The Proportion of the Fluid, in the Cavity of the Aorta, at the Origin of the Emulgents, to its containing Coat Exp. XXVI. § 2.

The Proportion of the Fluid in the Cavity of the Aorta, at the Origin of the Iliacs, to its Coat Exp. XXVI. § 2.

The Proportion of the Fluid in the Cavity of the Iliac Artery to its containing Coat Exp. XXVI. § 2.

Theſe Proportions compared Exp. XXVI. § 3.

The Structure of the Aorta and the Branches thence ariſing conſidered
In what remarkably different
The Reaſon and Neceſſity of this different Mechaniſm
The Increaſe of Capacity in the Branches at every Diviſion of the Trunk, ſhewn indiſpenſably neceſſary, both to the Life and Structure of the Animal
Exp. XXVI. § 6.

The Strength of the Vena cava, at the Origin of the Emulgent Veins, compared with that belonging the ſame Veſſel of equal Area, at the Origin of the Iliacs Exp. XXVII. § 5, 6.

The Strength of the Iliac Vein, compared with that belonging the Vena cava at the Iliacs, of equal Area Exp. XXVIII. § 3, 4.

The remarkable Structure of the Vena cava, near the Origin of the Emulgent Veins, both as to its Capacity and Thickneſs Exp. XXVIII. § 8.
Exp. XXXIII. § 9.

The Reaſon and Neceſſity of this Mechaniſm conſidered Exp. XXVIII. § 9. Exp. XXXIII. § 14.
The Specific Gravity of the Aorta deſcendens in an Ewe, near the Origin of the Emulgent Arteries Exp. XVIII. § 3.
The Weight required to break an Inch of it Exp. XXII. § 2.
Its Thickneſs Exp. XXXII. § 1.
The Specific Gravity of the correſponding Vein Exp. XVIII. § 4.
The Weight required to break an Inch of it Exp. XXIII. § 2.
Its Thickneſs Exp. XXXII. § 1.
The preceeding Articles relating to this Artery and Vein compared Exp. XXIII. § 3, 4.
The Specific Gravity of the Aorta deſcendens in an Ewe, near the Origin of the Iliacs Exp. XIX. § 3.
The Specific Gravity of the correſponding Vein Exp. XIX. § 4.
The Aorta deſcendens in an Ewe, near the Origin of the Iliacs, an Inch in length, what Weight it ſuſtained on breaking Exp. XXIX. § 2.
The Iliac Branch of the foregoing Artery tried in the ſame manner Exp. XXX. § 2.
The Strength of theſe compared in equal Areas Exp. XXX. § 3, 4.
The Thickneſs of the Iliac Artery in an Ewe Exp. XXXII. § 1.
The Thickneſs of the correſponding Vein Exp. XXXII. § 1.
The Weight required to break an Inch length of the Iliac Vein Exp. XXXI. § 2.

The

The preceding Articles relating to this Artery and Vein compared Exp. XXXI. § 3, 4.

Anatomiſts, their Concluſions on the Strength of the Veins ſhewn to be falſe Exp. XXXII. § 3, 4.

The Specific Gravities of the Aorta deſcendens, near the Origin of the Emulgent and of the Iliac Arteries in a Male Animal, compared with thoſe of the like Veſſels in a Female Exp. XVIII. XIX. § 3.

The Specific Gravities of the Vena cava, near the Emulgent and Iliac Veins in a Male Animal, compared with thoſe of the like Veins in the Female Exp. XVIII. XIX. § 4.

The Difference in the Denſities between the Arterial Veſſels in a Male and a Female, much more conſiderable than what ſubſiſts between the Denſities of the Veins, in the two Animals Exp. XIX. § 6, 7.

The Strength of the Aorta, at the Origin of the Emulgent Arteries in a Male, compared with that belonging the like Veſſel of equal Area to it, in the Female Exp. XXII. § 3, 4.

The Strength of the Aorta at the Origin of the Iliac Arteries in a Male, compared with that belonging the like Veſſel in the Female Exp. XXIX. § 3, 4.

The Strength of the Iliac Artery in a Male, compared with that of the like Veſſel, in the Female Exp. XXX. § 5, 6.

The Strength of the Aorta below the Emulgents and of the Iliac Arteries in a Female, comparatively weaker than the ſimilar ones in the Male Exp. XXX. § 7.

The

The Capacities of the Aorta below the Emulgents and of the Iliac Arteries in a Female, comparatively larger than the ſimilar Veſſels in the Male Exp. XXX. § 8.

The Reaſon of this different Structure conſidered
Its Uſefulneſs in the State of Pregnancy to the Female } Exp. XXX. § 9.

The Proportions of the Fluid contained in the Cavity of the Aorta, at the Origin of the Emulgent Arteries, and at the Origin of the Iliacs in a Male, to their reſpective Coats, compared with the Proportions belonging the like Veſſels in a Female Exp. XXXII. § 2.

The Bulk of the Arterial Coats in a Female, with reſpect to their original Trunk, bear nearly the ſame Proportion as thoſe in a Male do to the like Veſſel Exp. XXXII. § 5.

The Reaſon and Uſe of this Mechaniſm ſhewn Exp. XXXII. § 6.

The Strength of the Vena cava near the Emulgents in a Male, compared with that belonging the like Veſſel in the Female Exp. XXIII. § 5, 6.

The Vena cava and Iliac Vein, with relation to their correſponding Arteries, ſhewn to be ſuperior in Strength in a Female, to the like Veins in a Male, with reference to the Strength of their correſponding Arteries Exp. XXXI. § 8.

The different Texture of the Solids in Male Animals, from thoſe of Females, conſidered Exp. XXXII. § 8.

The Diſeaſes, to which each of them, from this different Mechaniſm and Texture, will be more peculiarly liable Exp. XXXII. § 9.

The Capacity of the Vena cava aſcendens and deſcendens, with reſpect to thoſe of an equal length of their correſponding Arteries in a Male, compared with the Capacity of the like Veſſels in a Female, with reſpect to their correſponding Arteries Exp. XXXIII. § 5.

The Capacity of the Vena cava near the Emulgents, and of the Iliac Vein, with reſpect to that of an equal length of their correſponding Arteries in a Male, compared with the Capacity of the like Veins in a Female, with reſpect to their correſponding Arteries Exp. XXXIII. § 7.

The Capacity of the Aorta deſcendens, with reſpect to that of an equal length of the Aorta aſcendens in a Male, compared with the Capacity of the like Veſſels in a Female Exp. XXXIII. § 6.

The Proportions of the Fluid, contained in the Cavity of the Aorta aſcendens and deſcendens, to their reſpective Coats in a Male, compared with thoſe belonging the like Veſſels in the Female Exp. XXXIII. § 8.

The Circulation of the Blood in Females, its comparative Slowneſs with regard to that in Males, to what Cauſes owing Exp. XXXIII. § 10, 12.

The different Proportion, which the Capacities of the Veins, with reſpect to that of their correſponding Arteries, bear in Females, to that of the like Veſſels in Males, ſhewn to be highly uſeful and neceſſary Exp. XXXIII. § 12.

Dr.

Dr. Pitcairn's *and* Freind's *Obſervation on the different Capacities of the Arteries, which proceed from the Heart in human Bodies of different Sexes, ſhewn to be no leſs true in Brutes* Exp. XXXIII. § 13.

The Strength and Thickneſs of the Arterial Veſſels, how affected with a ſmall Increaſe of their Diameters Exp. XXXII. § 10, 11.

The great Strength of the Arteries with reſpect to the Preſſure of the Fluids upon them, its great Uſe and Advantage to the Life and Safety of the Animal Exp. XXXII. § 12.

The Inconveniences, which would attend a weaker Structure of the Veſſels, conſidered Exp. XXXII. § 12, 15.

Fevers, why ſometimes of Service to the Conſtitution Exp. XXXII. § 16.

Spring Fevers and Intermittents, their Power to remove Obſtructions, and promote the Growth of young Animals, when probable Exp. XXXII. § 17.

The Splenic Artery an Inch in length, taken from a human Body, what Weight it ſuſtained at the Inſtant of its breaking Exp. XXXIV. § 2.

The correſponding Vein an Inch in length, what Weight it ſuſtained on breaking Exp. XXXV. § 2.

The Capacity of the Splenic Artery an Inch in length Exp. XXXIV. § 2.

The Capacity of the correſponding Vein of equal length Exp. XXXV. § 2.

The preceeding Articles, relating to this Artery and Vein, compared Exp. XXXV. § 3, 4. Exp. XXXIX. § 6.

The

The Splenic Artery, an Inch in length, taken from an Ewe, with what Weight compreſſed at the Inſtant of its breaking Exp. XXXVI. § 2.
Its Thickneſs Exp. XL. § 1.
The Weight with which the correſponding Vein an Inch in length was compreſſed, when Air paſſed freely thro' its Coats Exp. XXXVII. § 2.
Its Thickneſs Exp. XL. § 1.
The preceeding Articles relating to this Artery and Vein compared Exp. XXXVII. § 2.
The Strength of the Splenic Artery, compared with that belonging other Arteries in the ſame Animal, not preparatory to any Secretion Exp. XXXIV. § 3, 4. Exp. XXXVI. § 4, 5.
The Texture of the Splenic Artery, compared with that of the Aorta in the ſame Animal Exp. XLI. § 9.
The Proportion of the Fluid in the Cavity of the Splenic Artery to its containing Coat Exp. XL. § 3.
The Proportion of the Fluid in the Splenic Artery to its containing Coat, compared with the Proportions, which the Fluids in other Arteries, of the ſame Animal, not preparatory to any Secretion, bear to their reſpective Coats Exp. XL. § 3.
The Strength of the Splenic Vein compared with that of a common Reductory Vein in the ſame Animal Exp. XXXVII. § 3, 4.
The Capacity of the Splenic Vein, with relation to that of an equal length of its correſponding Artery, compared with that of a common Reductory Vein,

Vein, with relation to its correſponding Artery Exp. XXXIX. § 6.
The Bulk of the Solids in the Splenic Vein, with reſpect to the Fluid contained in its Cavity, compared with the Bulk of the Solids of a common Reductory Vein in the ſame Animal, with reſpect to the Fluid contained in an equal length of this Vein Exp. XL. § 4.
The Emulgent Artery taken from a Ram, with what Weight compreſſed at the Inſtant of its breaking Exp. XXXVIII. § 2.
Its Thickneſs Exp. XL. § 1.
The correſponding Vein, what Weight it ſuſtained, when Air paſſed freely thro' its Coats Exp. XXXIX. § 2.
Its Thickneſs Exp. XL. § 1.
The preceeding Articles relating to this Artery and Vein compared Exp. XXXIX. § 3, 4.
The Emulgent Artery taken from a Dog, with what Weight compreſſed at the time of breaking Exp. XLV. § 2.
Its Thickneſs Exp. XLVII. § 1.
The correſponding Vein with what Weight compreſſed, at the Inſtant of its permitting Air freely to eſcape thro' its Coats Exp. XLVI. § 2.
Its Thickneſs Exp. XLVII. § 1.
The preceeding Articles relating to this Artery and Vein compared Exp. XLVI. § 5, 6.
The Strength of the Emulgent Artery, compared with that belonging other Arteries in the ſame Animal, not deſtined for Secretion Exp. XXXVIII. § 4, 6. Exp. XLV. § 3, 4.

The

The Proportion of the Fluid in the Cavity of the Emulgent Artery to its containing Coat in different Animals Exp. XL. § 3. Exp. XLVII. § 3.

The Bulk of the Solids in the Emulgent Artery, with reſpect to the Quantity of Fluid they act on, compared with the Bulk of the Solids in other Arteries of the ſame Animal not deſtined for Secretion, with reſpect to the Quantity of Fluid acted on by theſe, in equal Lengths to the former Exp. XL. § 2.

The Strength of the Emulgent Vein, compared with that of a common Reductory Vein not deſtined to convey the Blood from any Secretory Organ Exp. XVI. § 3.

The Strength of the Emulgent Vein with reſpect to the Strength of its correſponding Artery, compared with the Strength of other Veins not deſtined to return the Blood from any Secretory Organ, with relation to the Strength of their correſponding Arteries Exp. XXXIX. § 5.

The Capacity of the Emulgent Vein in different Animals, compared with that belonging an equal Length of the correſponding Artery in each reſpectively Exp. XXXIX. § 7. Exp. XLVI. § 9.

The Capacity of the Emulgent Vein with reſpect to that of an equal Length of its correſponding Artery, compared with thoſe belonging common Reductory Veins in the ſame Animal, with relation to the Capacities of their correſponding Arteries Exp. XXIX. § 7. Exp. XLVI. § 9.

The Bulk of the Solids in the Emulgent Vein of different Animals with reſpect to the Quantity of Fluid contained in their reſpective Cavities, compared with the Bulk of the Solids of common Reductory Veins in each, with relation to the Quantity of Fluid contained in an equal Length of theſe Veins reſpectively Exp. XL. § 4. Exp. XLVII. § 3.

Dr. Keil's *Eſtimation of the Quantity of Blood in an Animal Body conſidered* Exp. XL. § 5.

The Animal Body, its Structure not to be aſcertained without a great Variety of Experiments Exp. XL. § 5.

Animal Secretions impoſſible to be ever ſolved by any general Hypotheſis Exp. XL. § 6.

The Pia Mater taken from a ſmall Dog, what Weight a Part of it ſuſtained at the Inſtant of its breaking Exp. XXXII. § 13.

Its Thickneſs Exp. XXXII. § 13.

The Pericardium in the ſame Animal, with what Weight an equal Part of it was compreſſed at the Inſtant of its breaking Exp. XXXII. § 14.

Its Thickneſs Exp. XXXII. § 14.

Theſe compared Exp. XXXII. § 14.

The Strength of the Pia Mater and Pericardium, compared with that belonging a Portion of the Aorta of the ſame Animal Exp. XLIV. § 7.

The miſerable State of the Animal had the Solids been formed more lax and weak Exp. XXXII. § 12.

Diſorders in the membranous Parts, why attended with the moſt acute Pains Exp. XLIV. § 8.

The Senſation of Pain, where like Parts in different Perſons are affected with the ſame Diſorders, why ſo very different Exp. XLIV. § 9.

Diſeaſes of the ſame kind in different Perſons, why much eaſier removed in ſome than others Exp. XLIV. § 9.

The Vena Portæ, an Inch in length, taken from different Animals, with what Weight compreſſed, at the inſtant Air eſcaped through its Coats Exp. XLI. §. 2, Exp. XLIV. § 2.

Its Thickneſs in each Animal Exp. XLIV. § 7. Exp. XLVII. § 4.

Its Strength in each, compared with that belonging the Vena Cava, the Splenic, and Emulgent Veins in equal Areas, reſpectively Exp. XLI. § 3, 4, 7, 8. Exp. XLIV. § 5, 6.

The Texture of the Vena Portæ in each, compared with that of the Aorta deſcendens in the ſame Animal Exp. XLI. § 9. Exp. XLIV. § 7.

Anatomiſts, their Error in making haſty Concluſions on the Animal Structure Exp. XLI. § 10.

The thinneſt and ſmalleſt Veſſels in general proportionally much ſtronger than others, that are far ſuperior in Capacity and Thickneſs Exp. XLI. § 10.

The Strength of the Vena Portæ in different Animals, compared with that belonging the Aorta of equal Area in the ſame reſpectively Exp. XLI. § 5, 6. Exp. XLIV. § 3, 4.

The Proportion of the Fluid in the Cavity of the Vena Portæ in different Animals, to the reſpective containing Coat in each Exp. XLVII. § 4.

The Bulk and Strength of the Solids of the Vena Portæ in different Animals, with relation to the Fluid propelled by them, compared with the Bulk and Strength of the Solids in ſeveral Arteries and Veins, with relation to the Fluid propelled by theſe, in each Animal, reſpectively Exp. XLVII. § 5.

The more remote Branches of the Arteries, their State examined Exp. XLVII. § 6.

Their Strength in Proportion to their Bulk, greater than that of the Trunks they are derived from, and why Ibid.

An increaſed Proportion of Strength in the Arterial Coats at every Diviſion of the Trunk, ſhewn requiſite to the nature of Animal Secretion Ibid.

Shewn agreeable to the Texture of the Secretory Organs Ibid.

The Arteries preparatory to Secretion, different from thoſe not deſtined to any ſuch Office, and why Ibid.

The different Mechaniſm in the Arteries preparatory to Secretion, ſhewn neceſſary to the due Separation of the Fluid, of whatever kind it be Ibid.

The Veins deſtined to convey the Blood back from any Secretory Organ, different from common Reductory Veins, and why Ibid.

The Texture of theſe Veins in the Gland and at their Union with the Artery, why probably very different from what they appear out of it Ibid.

Accidental Hurts perverting the Structure of the Gland alone, why attended with ſuch ill Conſequences Exp. XLVII. § 6.

When capable of being prevented Ibid.

The Animal Secretions, by what Contrivance produced in their due Quantity and Quality Ibid.

How changed from their natural State by an increaſed or diminiſhed Circulation of the Blood Ibid.

An Objection drawn from the Valves placed in ſuch Veins as return the Blood from the Secretory Organ, ſtated Ibid.

This Objection conſidered at large, and the true Uſe of the Valves in the Reductory Veins of the Secretory Organs aſcertained Ibid.

The Uſe of the Valves in ſuch Veins as lie very remote from the Secretory Organs, and in the Lymphatics, explained and compared with the former Ibid.

The Uſe aſcribed to them by ſeveral Anatomiſts falſe, and why Ibid.

Particularities relating to the Structure of the Vena Portæ hitherto unobſerved by any Writers Ibid.

The Reaſon and Neceſſity of this Mechaniſm in the Vena Portæ for the Separation of the Bile Ibid.

The Vena Portæ deſtitute of Valves, and why neceſſarily ſo Ibid.

The Vein returning the Blood back to the Heart after the Separation of the Bile, its Structure particularly conſidered Ibid.

In what different from the Reductory Veins of other Secretory Organs Exp. XLVII. § 6.
The great Uſe of this different Mechaniſm ſhewn Ibid.
Obſtructions in the Abdominal Glands when, and by what Methods curable Exp. XLVII. § 7.
When rendered incurable by the ſame means Exp. XLVII. § 7.
The Specific Gravity of the Cryſtalline Humors taken from the Eyes of an Ox Exp. XLVIII. § 5.
The Specific Gravity of the Nuclei of the ſame Humors Exp. XLVIII. § 6.
The Specific Gravity of the Capſulæ including the Cryſtalline Humors Exp. XLVIII. § 7.
Theſe Particulars compared Exp. XLVIII. § 6, 7.
The Denſity of the Cryſtalline Humor, how far abſolutely neceſſary to Viſion Exp. XLVIII. § 8.
Glaſs ſubſtituted by Optical Writers for the Cryſtalline Humor, why very improperly Exp. XLVIII. § 9.
The great Inequality both in the Denſity and Conſiſtence of the Cryſtalline neceſſary to Viſion, and why Exp. XLVIII. § 10.
The Vitreous Humor from an Ox's Eye, its Specific Gravity Exp. XLIX. § 2.
The Cohæſion of its Particles examined Exp. LII. § 1, 2.
Theſe compared Exp. LII. § 3.
The Vitreous and Cryſtalline Humors, their Specific Gravities compared Exp. XLIX. § 3.
The Vitreous Humor, its Denſity and Situation neceſſary to promote the Action of the other Mediums

Mediums joined with it, and the more equable Refraction both of Homogeneal and Heterogeneal Rays Exp. XLIX. § 5.

The Cohæſion of its Particles not intended to retard the Motion of Light to the Retina Exp. LII. § 4.

To what Uſes it moſt probably ſerves Exp. LII. § 4.

The Refractive Powers of the Aqueous, Cryſtalline, and Vitreous Humors in Proportion to their Denſities aſcertained Exp. XLIX. § 4.

The Cornea its Specific Gravity, compared with that of the Capſula of the Cryſtalline Humor in the ſame Animal Exp. L. § 1.

The Cornea, with what Weight compreſſed when Air paſſed thro' its Coats Exp. L. § 2.

Its Thickneſs Exp. LI. § 1.

The Capſula of the Cryſtalline Humor, what Weight it ſuſtained at the inſtant of its breaking Exp. L. § 3.

Its Thickneſs Exp. LI. § 1.

The preceeding Articles relating to theſe Membranes compared Exp. L. § 3.

The Mechaniſm of theſe Membranes, how far neceſſary and conducive to Viſion Exp. L. § 4.
Exp. LI. §. 2.

The Retina, its Thickneſs Exp. LI. § 1.

A Compariſon of this with that of other Membranes in the Eye Exp. LI. § 3.

Its extreme Thinneſs ſhewn abſolutely neceſſary to Viſion Exp. LI. § 4.

The Foundation of all Ideas acquired by Sight, on what ſtrictly and ſolely depending Exp. LI. § 4.

Optical Writers their Miſtake in aſſigning the efficient Cauſe of Viſion Exp. LI. § 5.

The Retina, its Concave Spheroidical Figure not owing to the Form of the Eye itſelf, but given it by Deſign Exp. LI. § 6.

This Figure demonſtrated to be the beſt poſſible Exp. LI. § 6.

The Camera obſcura, how far inferior in the Images repreſented by it, to thoſe delineated on the Curvilineal Surface of the Retina Exp. LI. § 7.

The Dimenſions of an Ox's Eye, and the ſeveral component Parts accurately taken Exp. LIII. § 1, 2.

The ſame conſtructed and delineated Exp. LIII. § 3.

To what Variations neceſſarily ſubject Exp. LIII. § 4.

Optical and Anatomical Writers, their Miſtake in aſcribing a Variation of Place to the Cryſtalline, and of Denſity to the Vitreous Exp. LIII. § 4.

Such Variations ſhewn inconſiſtent with the Structure of the Eye, and contrary to Fact Exp. LIII. § 5.

The Pupil, its Dimenſions variable, and why Exp. LIII. § 6.

Not intended to affect the apparent Magnitude of an Object Exp. LIII. § 6.

The miſerable State of the Animal, did ſuch a Power attend the Variation of the Pupil Exp. LIII. § 7.

Boerhaave*'s Notion of Light, ſhewn inconſiſtent with the Formation of the Eye itſelf* Exp. LIII. § 8.

The Uvea in the Eye of an Ox, with what Force its internal Muſcular Ring muſt contract, to raiſe the Vertex of the Cornea $\frac{1}{20}$ *of an Inch* Exp. LIV. § 1.

This Muſcular Ring, with what Weight ſeparable from the Cornea Exp. LV. § 2.

Its Strength ſufficient to undergo the neceſſary Contraction, for raiſing the Arch of the Cornea to a proper degree of Convexity Exp. LV. § 3.

The great Uſe of this Mechaniſm to Viſion in general Exp. LV. § 4.

Anatomiſts, their Miſtake with relation to the Uſe aſſigned by them to the Muſcles of the Eye Exp. LV. § 4.

Viſion in the human Eye how limited Exp. LV. § 5.

Such a Limitation abſolutely neceſſary to the well Being of Man Exp. LV. § 5.

Microſcopes, their Foundation and Uſe Exp. LV. § 6.

FINIS.

ERRATA.

PAGE 2. Line 11. *for* even, *read* in. p. 8. l. 8. and elſewhere, *for* cava, *r.* Cava. p. 53. l. 15. *for* ad, *r.* to. p. 65. l. penult. *for* Vena of, *r.* Vena Cava of. p. 91. l. 9. *r.* thus, ſhewn (at Exp. XIV. XV. and XIX.) p. 178. l. penult. and elſewhere, *for* Porta, *r.* Portæ. p. 210. l. 12. *for* Preparation, *r.* Separation. p. 224. l. 18. *for* in, *r.* on. p. 234. l. 17. *for* had it returned, *r.* had it been returned. p. 236. l. 4. *for* their, *r.* the.